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ON CHEMICAL DURABILITY

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NO MATERIAL can be exposed to the elements without undergoing chemical decomposition of some sort. This statement is as true of glass as it is of any substance, although if properly compounded, window glass will withstand exposure to the elements for years without serious change. Glass containers must withstand the action of hot water, fruit juices and various weak chemicals, while laboratory glass must withstand severe temperature changes and the action of strong acids and alkalies.

The deterioration of a glass surface with use has been variously called weathering, solubility, chemical stability and so forth. Just what happens during the disintegration of the surface is not known. It is a sort of leaching out of the alkali constituents accompanied by chemical changes of the silicates. The action is seldom uniform and is generally confined to a very thin layer of the surface. In cases of very bad attack the surface becomes opaque and may peel off in thin whitish flakes. Generally, however, the attack, under ordinary conditions of service, is confined to a dulling of the brilliancy and to the appearance of an iridesence of the surface.

Since glass owes much of its usefulness to its ability to withstand this sort of disintegration, many laboratory tests have been devised to measure this quality. Quite naturally the exact conditions of service cannot be duplicated. Even if they could, data so obtained would be of little value because of the exceedingly long time required. Some sort of accelerated test must be employed. The rate of attack is greatly increased if the temperature is raised. Because of this, most tests are conducted at an elevated temperature—usually near the boiling point of water, if conducted at atmospheric pressure, or above if an autoclave is used.

It has been noted that the surface of glass exhibits more resistance to disintegration than the glass below the surface. This is surprisingly well demonstrated if a scratched or injured glass article is subjected to an autoclave test. The original surface will be dulled and more or less eaten away but the scratch or chip will appear as a relatively large white scar sometimes accompanied by breaking out of chips of glass. The differential action thus observed has caused one class of investigators to insist upon tests of the surface only, wherein a finished article such as a bottle is tested, or wherein a special surface is formed on the glass sample by grinding and polishing in a controlled manner. If tests are made directly upon the original surface, the area exposed is always small so that it is difficult to detect changes in a quantitative manner, unless either a very long time is involved or a greatly accelerated type of test, such as an autoclave test, is used. Experience has indicated that greatly accelerated tests do not always give a value which corresponds to the serviceability or "Chemical Durability" of the surface in actual use. With the same type of glass, however, the results are in the same order of merit and tests are useful as a guide.

The surface of the glass may be increased by crushing the sample to powder, screening out the fine and coarser particles and conducting the test on some selected size of grains. Such tests are usually referred to as "the powder method" and are quite generally used. They of course, test the surface of a fresh crack as differentiated from the original surface. It has been found, however, that the results obtained by this method give results which enable glasses of poor chemical durability to be differentiated from glasses which will give satisfactory service.

From the above it can be seen that a very large variety of tests may be used. It is not the purpose of this article to describe or enumerate the different methods of testing. Briefly they may be divided as follows:

(1) Tests of the original surface as manufactured.
(2) Tests of an especially prepared surface such as a ground and polished surface.
(3) Tests of a crushed sample in which the surfaces are primarily those of the cracked main body of glass.

In addition, the methods of testing may consist of:
(a) Boiling in distilled water for a definite time at atmospheric pressure.
(b) Subjecting the samples to vapor at a definite temperature.
(c) Subjecting them to saturated steam at elevated temperature and pressure.
(d) Using dilute solutions of alkali or acid instead of water.

The method of evaluating the results may consist of:
(1) Determining the change in weight of the sample before and after testing.
(2) Determining the alkali liberated by titration.
(3) Determining the material dissolved by evaporating to dryness and weighing.
(4) Visual examination of the surface.

The desirability of standardizing on a few methods of testing is self evident since the number of combinations

which may be made from the above outline is very great and without standard methods the results obtained by one laboratory are not comparable to those of another laboratory. Such a condition leads to confusion and duplication of effort.

The problem of chemical durability is as old as the glass industry. Every glass maker has run into difficulties from weathering at various times. The art glass manufacturer has had difficulty with decorating which in many cases is due to weathering of the surface before the gold or silver was applied. The mirror manufacturer has found glass which would not take a perfect silver coat. This may have been due to weathering. Long storage or packing in wet hay have caused trouble from a milkiness of the surface which would not wash off. Many of the older windows have become dulled so that washing will not restore a brilliant surface.

Lamp workers have found that old glass tubing cannot be welded or reworked in the flame because of a dull skin which seemed to have formed on the tube. All of these effects may be accounted for by weathering or chemical disintegrating of the surface.

The metals have always given trouble from rusting. Certain surface treatments such as Parkerizing, Bonderizing etc., have been applied which greatly increase their resistance to corrosion. Similarly, many attempts have been made to improve the surface of glass by some kind of chemical treatment. One of the oldest is the "acid dip" for window glass. In this process the freshly made sheet is dipped in a dilute solution of muriatic acid and then washed in water. The acid removes any free alkali near the surface and leaves behind a surface higher in silica which is somewhat less hygroscopic and more resistant to weathering. More recently it has been claimed that certain gases in the lehr such as sulfur dioxide will increase the resistance of glasses so treated to disintegration.

The water used in grinding and polishing plate glass probably removes some of the surface alkali and thus makes the surface more resistant.

No method, however, has ever been devised which will make serviceable glass from glass of inherently poor chemical durability. The effort should be spent in correcting the chemical composition of the glass so that a truly durable glass is manufactured.

Even if surface treatment were successful in reducing disintegration the method would have only limited usefulness, first because the surface is bound to be marred and chipped in service and secondly, because most articles are hollow or irregular in shape and the treatment would probably be more expensive than a change in composition that would enable inherently resistant glass to be manufactured.

WHEN one considers the compounds from which glass is made it is exceedingly fortunate that durable glass can be manufactured at all. Silica is the largest constituent in most commercial glasses. This is one of the most stable elements in nature. It is, however, too refractory to be melted so that a flux such as soda must be added. Usually the ratio is between 10 and 20 per cent of soda to 65 to 80 per cent of silica. If these are melted together alone, a form of water glass results which is readily dissolved in warm water, and is hygroscopic and unstable in air. Fortunately there are stabilizing materials such as lime and alumina which can be used to replace some of the soda and which prevent the glass from dissolving. Lime is usually incorporated in bottle glass to the extent of 7 to 12 per cent and alumina from small amounts to 1 or 2 per cent. The proper ratio of silica, lime and alkali results in a glass which has a very good chemical durability.

THERE are a great number of factors, however, which must be considered when compounding a glass besides its chemical durability. These may be its meltability, its tendency to devitrify, or its working range; they may also be its refractive index as in optical glass, its color as in art glass or its ability to be worked in flame as tubing.

The method of manufacturing imposes certain definite physical properties which must be maintained and therefore limit the field of composition which may be employed. It is therefore futile to lay down a set of rules for compounding a chemically durable glass. Each composition is a compromise and often requires a great amount of experimentation before the most durable glass consistent with the required physical characteristics can be developed.

In general, the following changes increase the chemical durability of the glass:

(1) Reduction of the alkali.
(2) Increase in the lime.
(3) Addition of alumina.
(4) Small amounts of B_2O_3, BaO increase chemical durability.
(5) If the cost of the batch will permit PbO may be substituted for lime and the alkali reduced resulting in a more durable glass for the same degree of softness.
(6) Zinc oxide is a powerful stabilizing compound.
(7) If the alkali is made up of both soda and potash a more resistant glass results.

The exact effect of any addition is generally somewhat dependent upon the rest of the constituents of the batch. Usually it is not fair to compare the chemical durability of one glass with that of another unless the two glasses are the same in "hardness" for a soft glass is almost always less chemically durable than one which melts at a high temperature. Indeed, the problem, when chemical durability is the main factor, is usually to compound a glass which is soft enough to melt and yet has the required chemical durability.

Physically, glass is an undercooled liquid made mechanically rigid by an enormous viscosity. In several respects it, therefore, resembles a liquid. This is more and more true as the temperature increases. Thus, under an impressed electro motive force, the ions of alkali move with relative ease through heated glass, and the glass becomes a conductor of electricity. When a rod of glass containing soda is heated in a burner, soda vaporizes to such an extent that the flame is colored yellow. As soda passes off it is replaced from the interior of the glass so that no noticeable reduction in the amount of sodium flame emitted seems to occur. The sodium coloration usually develops about the time the surface reaches the softening point. Because of its viscosity, the glass tends to remain in the physical condition corresponding to a higher temperature while it is cooling. We would therefore expect rapidly cooled glass to permit freer migration

of the alkali ions than would carefully annealed glass. This expectation is substantiated by measurements of electrical conductivity. Likewise it is probable that rapidly chilled glass has less surface resistance to chemical attack than does carefully annealed glass.

A glass surface is quite hygroscopic. This property seems to depend primarily upon the alkali content of the glass. High lead, low alkali glass shows little electrical surface leakage under conditions where a harder soda lime glass is a relatively good conductor. It seems probable that among glasses of the same type, measurements of the surface conductivity under known conditions may be used as a guide to the chemical durability of the glass.

The fact that chemical attack is so rapidly increased by heat furnishes an explanation to a puzzling phenomenon often observed in laboratory beakers. The beaker is heated over a flame while filled with a solution. There may be a small pit in the bottom of the beaker. There exists under these conditions a severe temperature gradiant through the glass and the bottom of the pit is hotter than the remaining inside surface. The bottom of the pit is consequently more rapidly attacked than the remaining glass and some of it dissolves away. This brings the pit into still hotter glass and a further acceleration of the attack. Soon the effect is that of an autoclave and in the course of time a hole almost like a worm hole will be eaten through the beaker. This is a thermal effect and not a defect in the beaker as often supposed.

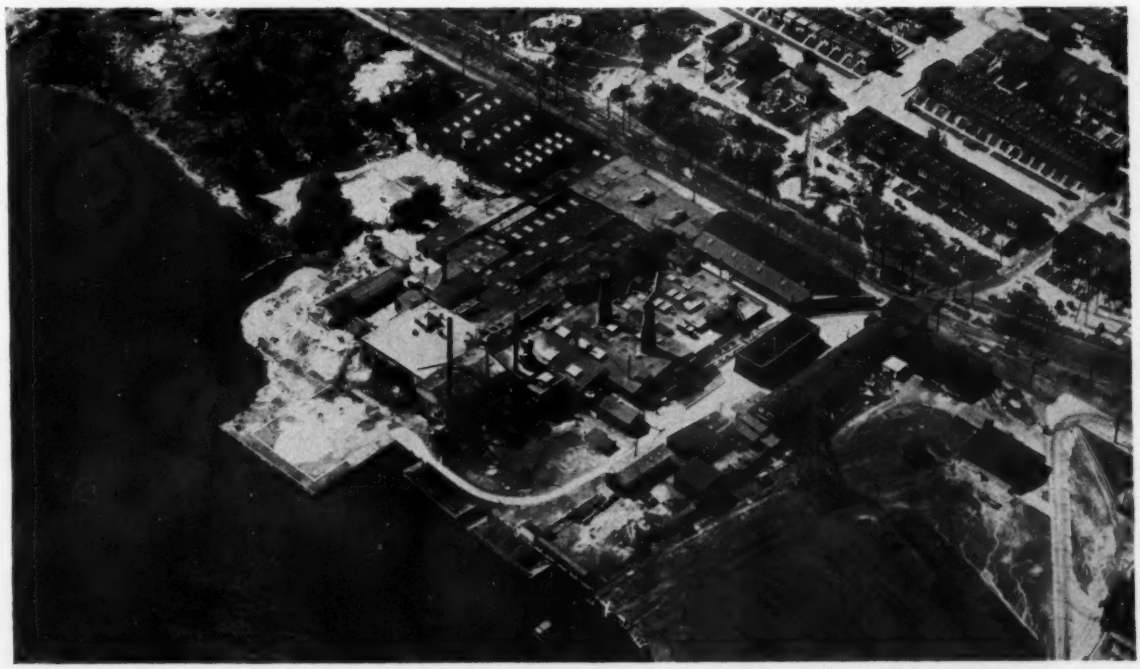
When tests made under different conditions are compared the acceleration of the attack by temperature must be considered. There is another factor which must also be taken into account. This latter is the diminution of the attack with time. Since glass is hygroscopic it collects upon its surface a layer of water vapor which is continually leaching out some of the alkali. Washing of the surface removes this alkali and there is less alkali available at the surface for a secondary attack. If a surface method of measuring the chemical durability is used on an old often washed specimen such as a used milk bottle, it is probable that the result will indicate a greater chemical durability than on a new bottle. If, however, the sample is stored several days and tested without being washed the result of the weathering which took place before testing will add itself to the test and a diminished chemical durability will be indicated. This variation exists only when the original surface is tested.

Many of the laboratories serving the glass industry both here and abroad are now investigating chemical durability. The problem is large and complex. It will be necessary to collect the available information, to devise some means of comparing the results obtained by different methods of testing, to establish the relation between laboratory results and the effects of actual use and finally to make an extended research on the effects of the glass forming oxides on the chemical durability of glass before it can be said the problem is completely solved.

POLISHED PLATE PRODUCTION

The total production of Polished Plate Glass by the member Companies of the Association for the month of July 1934, was 7,241,867 sq. ft., as compared to 6,520,081 sq. ft. produced by the same Companies in the preceding month, June 1934, and 11,350,393 sq. ft. produced by the Association members in the corresponding month last year, July 1933.

This makes a total of 55,131,138 sq. ft. produced by these Companies during the first seven months of 1934, as compared to 49,476,741 in the same months of 1933.



THE GLASS INDUSTRY FROM THE AIR

A view of the Carr-Lowrey Glass Company, Baltimore, Md., where glass containers are made both by machine and hand for the perfume, pharmaceutical and proprietary medicine industries.

THE COST OF ALUMINA FROM FELDSPAR

By S. R. SCHOLES
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THE glassmaker who plans to include alumina among the oxides composing his glass is offered a choice of raw materials to supply this oxide. A number of considerations enter the question. The material must be in physical condition to mix well, without danger of segregation. It is desirable that the material be not too dense and concentrated, since this works against homogeneity in the melt. It must dissolve readily during the fusion process.

These requirements are well met by feldspar, but it is not the purpose of this article to emphasize the advantages offered by feldspar as a batch-ingredient, but rather to demonstrate its economy in comparison with other materials of equal purity.

No one but a devotee of the "glaze-formula" style of calculation thinks of feldspar in terms of its chemical formula, $K_2O \cdot Al_2O_3 \cdot 6SiO_2$. As mined and ground on a commercial scale, it departs from the composition demanded by the orthoclase formula. However, the large producers exercise analytical control, so that any shipment may be relied upon to have a definite composition, within 0.5 per cent of any single oxide. For our purpose, it is fair to assume that we are dealing with a spar made up as follows:

Silica, SiO_2	68	per cent
Alkali, R_2O	13	" "
Alumina, Al_2O_3	18	" "

The remaining one per cent may be moisture (ignition loss), lime, baryta, and traces of other oxides—not deleterious, but also not entering the discussion of values as glass formers. The alkali is largely potash,—in its effect upon the glass in small amounts not greatly different from soda, and therefore to be regarded as only equivalent in value to as much soda.

Prices depend heavily upon the character of spar demanded, and upon freight rates. Accepting as a figure the top price quoted in The GLASS INDUSTRY, $13.00 per ton, and a freight rate of $5.00, making a delivered cost of $18.00 per ton, we may proceed to estimate the net cost of alumina per pound as follows:

Each ton of our feldspar contains:
Silica .68 ton, equivalent to glass sand, .68T.
Alkali, .13 ton, equivalent to soda ash, 448 lb.
Alumina, .18 ton, or 360 lb.
Cost of feldspar, $18.00.
Value of silica, replacing sand at $4.00 per ton, $2.72.
Value of alkali, replacing soda ash at $1.10 cwt., $4.92.
Total credits, $7.64.
Net cost of alumina, $10.36.
Cost of Alumina per pound, $.0288.

Comparative figures for alumina hydrate, assuming delivery at $80.00 per ton, and taking account of an alumina content of 65 per cent, with no other glass-forming oxides present, show a yield of 1300 lb. of alumina, at a cost of $.0615 per lb.

The GLASS INDUSTRY quotes aluminum oxide, sometimes called calcined alumina, at $.04 per lb.

Kaolin, a material of poor physical character for glass-making because of its tendency to lump and to roll into balls, should nevertheless be considered. Kaolin is not suitable for crystal glass, because it usually contains as much as 0.3 per cent iron oxide. Glassmaker's feldspars are often below 0.05 per cent in iron oxide content, and seldom exceed 0.1 per cent Fe_2O_3.

A good kaolin contains 38-39 per cent Al_2O_3, and 48-49 per cent SiO_2, and is quoted at $8.00 per ton at the mine. With freight at $5.00, the delivered price is $13.00 per ton. Against this is a credit of $1.96 for the sand-equivalent of the silica present, leaving the net cost of 780 lb. alumina $11.04, or $.0142 per lb. of alumina.

The cheapness of kaolin as a source of alumina is offset by its impurity and the danger of stone and cord-formation from the lumps and balls which it produces.

Feldspar shows an outstanding economy, as a material for introducing alumina into glasses where good color and clear quality are important.

Certain other aluminous minerals should be mentioned, although they have not as yet been offered to the glass industry in an acceptable uniformity of composition and freedom from iron, such as would warrant their adoption. We refer to bauxite, the best deposits of which are closely held for alumina manufacture; diaspore, chiefly valuable for refractories; kyanite, which contains a very high percentage of alumina, but likewise a high iron content, and which seems to find its proper field in producing mullite for refractories and other ceramic bodies; and some of the nephelines of Canada, which are not essentially different from feldspars with a high content of albite—the soda spar.

PITTSBURGH PLATE ACQUIRES MONTANA UNIT

The distributing warehouse system of the Pittsburgh Plate Glass Company was increased to 71 units by acquiring the business and property of the Montana Glass & Paint Company, Butte, Montana.

Operations by the Pittsburgh Plate Glass Company started August 1 at the same location—840 Utah Avenue, under the direction of Mr. R. H. Scott, Local Agent, and with the supervision of Mr. J. K. Wenham, Local Manager at Minneapolis.

T. C. WERBE SOON TO RETURN

T. C. Werbe, president of the Lynch Corporation, Anderson, Ind., has been spending the month of August in Colorado, where he has been recuperating from his recent operation. Mr. Werbe writes that he will soon be back at his desk to see the new Lynch factory at Anderson.

MEASUREMENT OF THE TRANSMISSION OF COLORED GLASSES

By H. W. LEE

Taylor, Taylor and Hobson

IT IS known that white light consists of a number of differently colored constituents because these are refracted differently by transparent substances, so that when sunlight is passed through a glass prism the constituents are separated and a "spectrum" is produced showing the following colors in the order of refraction: red, orange, yellow, green, blue, violet. Beyond the two ends of the visible spectrum there are invisible parts, the Infra-Red and Ultra-Violet regions. Their presence can be detected, as by the heating effect of the infra-red rays and the chemical action of the ultra-violet rays.

Transparent substances are colored because they differentially transmit the colors. Colored glasses may be classified according to use as (1) visual; for decoration, signalling or scientific purposes; (2) protective; as eye glasses to cut out glare from sun or snow, or to protect the eyes of furnacemen, welders etc; (3) photographic; to increase contrast, and for use in color photography and kinematography. For whatever purposes used it is important to know the amount and kind of "light" (whether visible or invisible) transmitted and this can only be determined by measuring the percentage transmission for every color of the spectrum. In practice this is done for a limited number of rays, and for some purposes it is sufficient to determine the transmission for an extended region of the spectrum.

For transmission measurements we require then, (1) a source of light; (2) a means of splitting the light into its constituent colors; and (3) a means of measuring the light: this will of course depend on the region of the spectrum dealt with. The source of light is nearly always an incandescent filament lamp as it is convenient and its brightness can be kept constant over a long period. For measurements on photographic filters the carbon arc is generally used as being rich in photographically active rays. The light splitter is called a spectrometer (Fig. 1) and consists of a collimator (C), a prism (P), and a telescope (T). The collimator is a tube with an illuminated slit at one end at the focus of a lens at the other, so that a parallel beam of rays emerges from the lens, which is refracted and dispersed by a prism

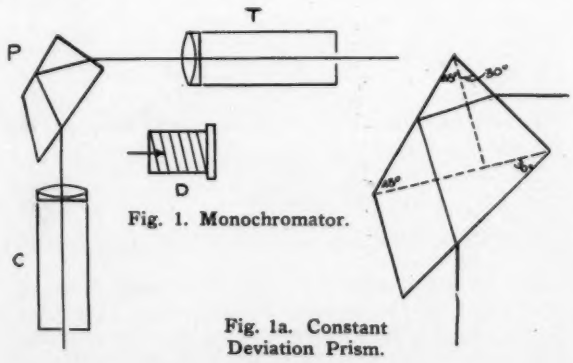
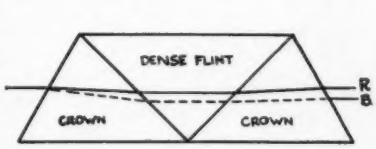
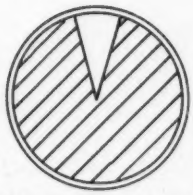


Fig. 1. Monochromator.

Fig. 1a. Constant Deviation Prism.





(left) Fig. 2. Direct Vision Prism. (right) Fig. 3. Sector.

and enters the telescope or a tube similar to the collimator so that a beam of colored light emerges from the second slit. The most convenient form is the "constant deviation" type, where collimator and telescope are at right angles, the prism consisting, as shown (Fig. 1a) of a 45° prism with a pair of 30° prisms cemented to it. The ray that is bent through a right angle is in minimum deviation. As the prism is rotated rays of different colors pass through the position of minimum deviation and emerge from the exit slit. The prism is rotated by a screw, the head of which carries a drum (D) with a scale of wave lengths marked on it, so that the wave length of the emerging light is known. This instrument is called a monochromator. Cheaper instruments are employed which are especially useful as portable instruments, in which a "direct vision" prism is used. This consists of at least three constituent prisms of which the inner is turned with its base in the opposite direction to those of the other two, so that it neutralizes their refraction, but being made of glass of high dispersion there is a certain amount of dispersion.

The amount of light transmitted by a glass is usually measured by dividing a beam of light into two beams which are reunited in juxtaposition in the eye, which is thus able to judge of any inequality of brightness. The intensity of the two beams is adjusted to quality and then the glass is inserted in one beam. This upsets the balance so that the other beam has to be diminished in intensity by a measurable amount till the balance is restored. The percentage absorption of the colored glass is then equal to the percentage diminution of the comparison beam. The method chiefly employed to diminish the intensity of a beam in visual work is to employ a pair of polarising prisms (called Nicol prisms). If the two prisms have their axes parallel light is transmitted; but if their axes are at right angles to one another (axes "crossed"), no light is transmitted. Between these two positions of the prisms the amount of light that gets through is proportional to the cosine of the angle between the axes, which is measured. Modern practice tends to replace the human eye (which is liable to become fatigued, and is always a little uncertain in its judgment), by the "electric eye"— the photoelectric cell. The two comparison beams are passed into two cells and the resulting currents made to balance.

Colored glasses are used to protect the eye from an excess of ultra-violet light as this produces conjunctivitis.

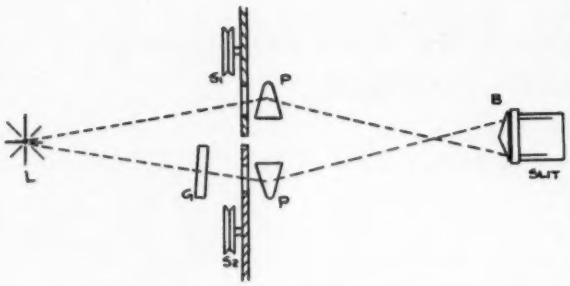


Fig. 4. Ultra Violet Spectrophotometry.

The efficiency of eye protecting glasses is determined by the completeness with which they absorb these harmful relations. The infra red rays also are not wanted, as these convey heat, and it is advisable for the comfort of the worker, to protect him from excessive heat; moreover these rays are probably the cause of the disease known as glass-blower's cataract. At the same time sufficient visible light must be transmitted to permit working in comfort. The infra-red radiation is measured by means of an instrument known as the thermopile, which is a sensitive instrument for detecting heat, and, therefore, infra-red rays. The thermopile is connected to a galvanometer which indicates the amount of heat falling on the thermopile by the degree of deflection. Measurement of the infra-red transmission of glasses is made by passing a beam of light through a screen which absorbs all the visible and ultra-violet light, leaving only the infra-red radiation which falls on the thermopile and produces a deflection on the galvanometer. The glass to be measured is next inserted in the beam and immediately the deflection of the galvanometer falls owing to the partial absorption of the glass. The ratio of the deflection with the glass to the deflection without is the proportional transmission. A range of 1:500 can easily be detected by these means. The range can be extended to 1:5,000 or more by the following device. A rotating sector, which is an opaque disc with a sector aperture, the angular extent of which can be varied and measured, is inserted in the beam; this cuts down the transmission to an amount equal to the ratio of the angle of the sector (Fig. 3) to the angle of the complete circle (360°). Let us suppose this is one tenth. The deflection of the galvanometer is arranged to be some suitable value say 500 divisions. The sector is next removed and its place taken by the glass to be measured. A movement of the mirror through one division indicates a transmission of one five thousandth of the original beam.

The method of measuring ultra-violet transmission is necessarily photographic. With protective glasses it is only necessary to know the total ultra-violet transmission, but with photographic filters the transmission for each part of the spectrum must be known. The photographic instrument corresponding to the spectrometer is the spectrograph in which the photographic plate replaces the eyepiece of the telescope. The lenses and prism are made of quartz which has greater ultra-violet transmission than glass. The method of measurement is one by which the absorption of the glass is balanced by the measurable absorption of a rotating sector. Light can reach the slit of the spectrograph by two paths (Fig. 4): through two rotating sectors S_1 and S_2; the aperture of the lower one S_2 is fixed while that of the upper, S_1 can be varied. Two spectra will thus be formed on the photographic plate, one above the other, the intensity of one of which can be varied at will by altering the aperture of the sector S_1. The absorbing glass is placed at G in the lower beam. A series of photographs is now taken with S_1 at various apertures, the plate being shifted between exposures. On development there is obtained a series of pairs of photographs of spectra, one of each pair being successively reduced in density while the other is the same throughout the series but has certain parts reduced or missing by the absorption of the glass. If a sufficient number of photographs has been taken it will be found that for every part of the spectrum a match can be made with one of the reduced spectra, the proportion of reduction of which is known by the aperture of S_1 with which it was taken; hence the percentage reduction by the glass for each part of the spectrum is found.

A convenient photographic method of representing the transmission of glass is to photograph the spectrum in a spectrograph with the specimen inserted in the beam and an absorbing wedge placed in front of the slit base up. The wedge transmits practically the whole of the radiation at the thin end and none at the thick end, so that the spectrum gradually fades away from bottom to top. A part of the spectrum which has been partly absorbed by the glass will then be completely absorbed by a certain thickness of the wedge so that its length will be only a fraction of that of unabsorbed radiation. Thus the transmission of the glass for any part of the spectrum will be proportional to the length of the spectrograph of that part. Such a spectrograph (Fig. 5) is called a "wedge spectrogram".

Standardization of Colored Glasses. Glasses for visual work include (beside those for decorative purposes which are not standardized) light filters for scientific use including microscopy, and signal glasses. For these it is usual to supply a curve showing the percentage transmission against wave length, or a wedge spectrogram.

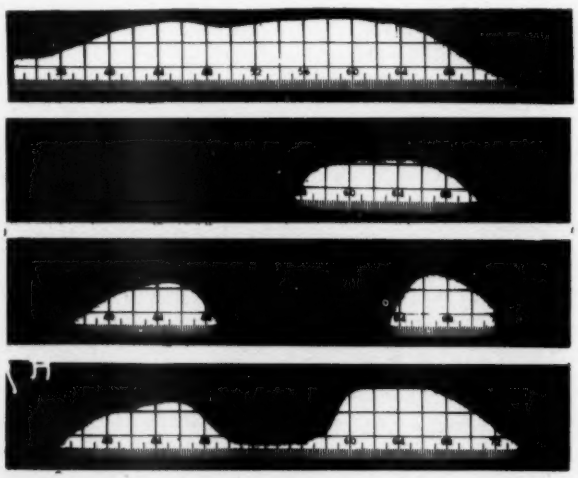


Fig. 5. Wedge Spectrograms with Wave Length Scale. (a) Unabsorbed Spectrum on Panchromatic Plate, (b) (c) (d). Spectra Transmitted by Filters (bright orange, purple, and pink, respectively). Courtesy of Ilford, Ltd., London, Eng.

Signal glasses include those for navigational, railway, road and air use. In order that a navigation signal lamp should be sufficiently bright to be visible at a distance, the British Board of Trade specify that the transmission should be not less than 10 per cent, and in order that the color should be plainly distinguishable, the transmission should not be more than 15 per cent, using a standard paraffin burner. The color is defined by the "dominant hue" and "saturation" terms that can best be explained by considering a specification. Thus the light green signal has a hue of 5055 Å and 52 per cent saturation; which means that its color can be matched by a mixture of 48 per cent monochromatic light of wave length 5055 Å together with 52 per cent white light. This test is carried out on an instrument called a spectrophotometer; in its simplest form (Fig. 6), a monochromator sends light of a selected wave length through a transparent reflector (R), which also reflects along the same path, white light from a lamp which has passed through a rotating sector (S_1), to vary its intensity. Another beam of light passes through a rotating sector (S_2) and the glass under test (G) along a path at right angles to the mixed beam. The two beams enter the eye in contiguous paths through a Lummer-Brodhun cube (B), which consists of two equal right angle prisms cemented together, the hypothenuse of one being silvered except for a small area. The mixture of white and monochromatic light is reflected, while the light from the signal glass passes through the small aperture. Thus the eye sees one colored field within the other. The wave length of the monochromator, and the apertures of the two sectors are varied till the two fields appear equal in color and brightness. The brightness and color of the glass are then completely specified by the wave length of the monochromatic light and the proportionate mixture of white light. The British Standards for Road Traffic Signals are experssed similarly in terms of the proportions of three "standard" colors adopted by the International Committee on Illumination. Thus the red signal glass must transmit light which contains not more than 0.325 of the standard green and not more than 0.001 of the standard blue. (As the factors for the three colors add up to unity it follows that there must be not less than 0.674 of the standard red). These factors are determined on a spectrophotometer in which the transmission is compared with that of a mixed beam of the three standard colors each of which can be adjusted in intensity by means of the rotating sectors. The British Standard also specifies that red transmittance should be not less than 8 per cent, amber not less than 25 per cent nor more than 60 per cent; and green not less than 8 per cent.

Photographic filters are usually considered to be specified with sufficient accuracy by means of wedge spectrograms. If more precise information is required; as for example in three color photography, curves giving percentage transmission against wave length are supplied. The Jena glass works made a comprehensive series of such glasses, but these have been ousted by colored gelatine filters which are much easier to make, so that glass filters for photography are almost confined to contrast filters of yellow or green glass absorbing the ultra-violet light to different degrees, and specified by the increase in exposure necessitated by their use. They are thus known as x2, x3, x5 filters.

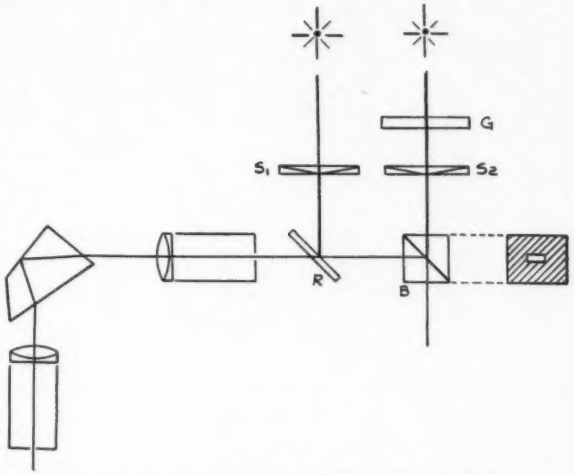


Fig. 6. Measurement of the Color of a Glass Filter.

In eye protective glasses color is of mere secondary importance. The Bureau of Standards has suggested grading these glasses by a series of numbers called "shade numbers". The density (D) of a glass is defined as the logarithm of the reciprocal of the transmission (T), thus

$$D = \log 1/T$$

Shade number is defined by W. W. Coblentz and R. Starr by the equation

$$\text{Density} = 3/7.\ (\text{Shade Number} - 1)$$

or

$$\text{Shade Number} = 7/3.\ \text{Density} + 1$$

(so that shade number 1 indicates Density O, or complete transparency). The following series of glasses is obtained by taking the limit of the range of transmission measurable as 1:400,000, and dividing this range into thirteen equal steps. The maximum density is 5.59, and 5.59/13 = 0.43, so that each step corresponds to a difference in density equal to 0.43. In Table 1 is shown the density, in the third column the percentage transmission as deduced from the density. The percentage Infra Red and Ultra Violet transmission tolerable is next given. In the last column is indicated the purpose for which the glass is suitable.

Shade No.	Density	Percentage Transmission Visible	Infra Red	Ultra Violet	Purpose
2	0.43	36.9			
3	.86	13.8	0.4	0.83	Light Brazing
4	1.29	5.1	.15	.8	Furnaces up to 1600°C
5	1.72	1.9	.05	.3	Goggles for Sunray Protection
6	2.15	.7	.02	.12	Lead burning. Acetylene welding, cutting & brazing
7	3.02	.095	.008	.02	Heavy actylene ditto
10	3.87	.013	.002	.002	Metal Arc
12	4.74	.0018	.0005	.0000	
14	5.59	.00026	.0001	0	Carbon Arc Welding

Note: At present a British Committee of the Engineering Standards Committee is drawing up similar standards for Great Britain.

THE CRYSTALLIZATION OF PSEUDOWOLLASTONITE BY DEVITRIFICATION OF GLASSES*

By MARCEL BELLIERE
S. A. Glaver, Moustier, s/S, Belgium

THE crystallization of pseudowollastonite during the devitrification of industrial glasses is often regarded as a rather rare event. This point of view is incorrect, and arises from the fact that in many instances this material escapes superficial examination. As a matter of fact, I have found pseudowollastonite in innumerable cases, and if by reason of the smallness of the crystals or their scarcity, they are less striking at first sight than the more massive crystals of wollastonite or devitrite[1], they often show curious formations which have been but little studied.

In an interesting article, H. Jebsen Marwedel describes the various types of crystals resulting from the devitrification of soda-lime glasses[2]. Among the species studied is found pseudowollastonite (designated in the article as α wollastonite) which is described in these terms: "Hexagonal plates, snow white, which, in side view, thin towards the center where a hole is found". The author comments that these crystals are so rare that they scarcely offer any interest in current practice.

The foregoing description, sufficiently brief, contains an error of detail; it is no doubt through an error of observation that the existence of a hole in the center of the plates is mentioned. I have studied a great number of pseudowollastonite crystals formed in glasses and other materials of diverse character, and I have never observed crystals with holes in them. Moreover, such a crystal form would be almost impossible to explain.

The existence of pseudowollastonite crystals in glass has been mentioned previously by H. Le Chatelier[3]. At a much earlier date, we read in a work, where, for the first time, maybe, crystals are mentioned in devitrified glass, a description which seems to apply perfectly to the hexagonal crystals of pseudowollastonite[4].

I have had occasion in an earlier note to give some remarks on the crystallization of this substance. The object of the present work is to describe more precisely certain details[5].

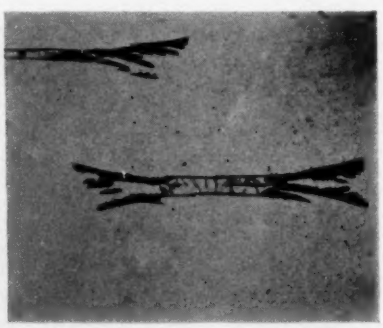
The smallest crystals of pseudowollastonite which arise in glass occasionally present the form of small but perfect hexagonal plates. Very good specimens are shown in a work by A. Dietzel[6]. Nevertheless, pseudowollastonite shows a great tendency to dendritic development. It appears that when the crystallizing takes place in a viscous or agitated medium, the little crystals present from the start a dendritic outline (Fig. 1).

Among the larger crystals one may observe around a transparent hexagonal plate a dendritic development of hexagonal outline (angles of 120°) whose form strongly reminds one of snow crystals. (Fig. 2) The crystal illustrated was taken from a manufactured article. I have often been able to observe similar ones in window glass, in polished plate glass or devitrified tank glass. They are very nearly invisible to the naked eye.

Among the still larger crystals the development of dendrites around the central hexagonal plate becomes more abundant, and nearly always presents a remarkable peculiarity; these dendritic increases do not form in the plane of the plate, but on either side thereof and separate more and more as they go outwards so that the dendritic coronets, instead of being planes, are a species of spherical segments with their cavities turned away from each other. A cross section of such a complex crystal therefore presents the appearance of figure 3. As a matter of fact the phenomenon is still more complicated; for the coronets are not just two in number, one towards one side and one towards the other, but now and then are much more numerous, the total grouping being formed by the juxtaposition of numerous fragments of dendritic crowns superposed, and to some extent overlapping, after the fashion of the petals of a flower whose center would be the original hexagonal plate.

Further, crystals in a fair state of development may present the form of a flattened prism several millimeters across, whose contour is hexagonal and a little hazy or faint, since it results from the superimposing of numerous leaflets more or less hexagonal, which do not always, or necessarily, have the same shape. The bases are hollowed out a little like an hourglass.

It is the superposition of these numerous dendritic leaflets, coupled with the fact that pseudowollastonite possesses an index of refraction very different from that of glass ($n_g = 1{,}650/n_p = 1{,}609$) * [7], which causes the comparative opacity of these formations and frequently gives



(left to right) Fig. 1. Small dendritic crystal in tank glass. (×61 transmitted light.) Fig. 2. Small crystal in polished plate. (×105 transmitted light.) Fig. 3. Cross section of a crystal formation in glass tank stopped for repairs. (×26 transmitted light.)

them a very white color as described by H. Jebsen Marwedel. The light is, so to speak, stopped by the mass of little fibers constituting the layers of superposed dendrites.

On the other hand, the central crystal plate, generally of a simple form, does not stop the light, because its faces are often smooth and very plane; it is therefore perfectly transparent and as its exterior contour is masked by the beginnings of the dendritic coronets, it is not in general visible at first glance, which explains how it has been possible to consider these formations as hexagons with holes in. A cross section of the complete object shows in the microscope the true form of the grouping and the existence of the central lamina (Fig. 3). Even flat-wise examination, with a microscope or a lens, nearly always suffices to demonstrate its presence, for its shows in many cases fractures or striations to which we shall

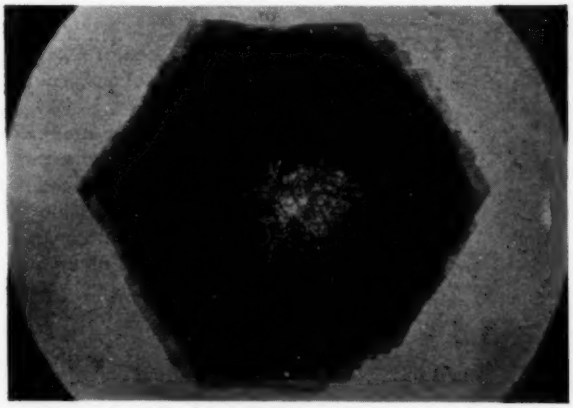


Fig. 4. Hexagonal grouping seen flatwise (axially) in window glass tank. (×24 transmitted light.)

return a little later. A thin section through a formation of pseudowollastonite taken parallel to the hexagon, will not cut as a rule anything but the dendritic zones, unless it be made perfectly in the median plane. Frequently one will have in the section nothing but the curved parts of the dendritic chaplets giving the characteristic appearance of H. Jebsen Marwedel's figure 15 in the article cited above, or the left part of Fig. 13 of this paper. If, on the contrary, the section is made in the median plane, it will meet the central hexagon and may even fail to show the dendritic coronets. A glance at figure 3 will show the appearance which sections parallel to the plane

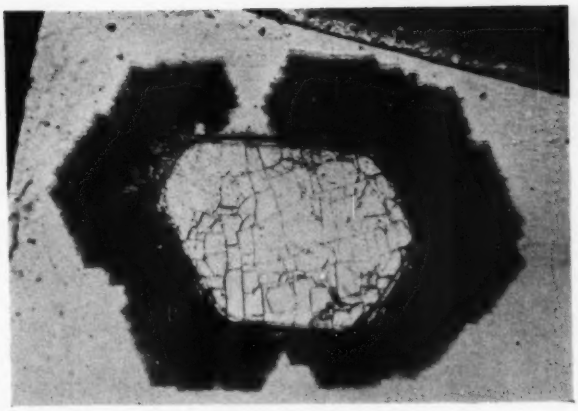


Fig. 5. Hexagonal grouping seen flatwise in window glass tank. (×24 transmitted light.)

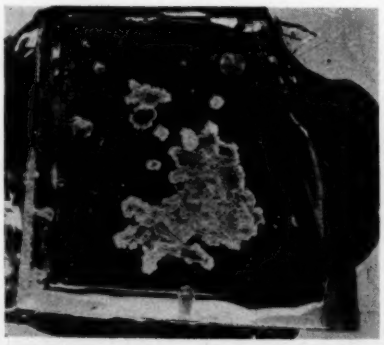
of the hexagon must present according to the part of the crystal intersected.

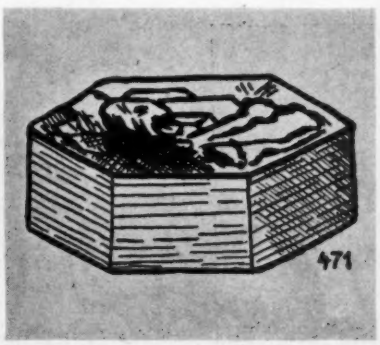
Figure 4 shows a complete crystal grouping; this is not a thin section, but a plate of glass which has been ground on its two faces down to the thickness of the crystal which it contains and then has been repolished. By reason of the description above, the marginal parts of the crystal intercept the light and appear nearly opaque in transmitted light. One may see at the edge of the photograph the contours of numerous dendritic coronets superposed.

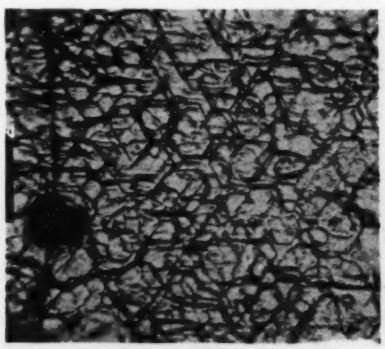
Figure 5 is a photograph taken under analagous conditions; here the central crystal, of greater extent and very transparent, shows a number of fine cracks.

The structure of the dendritic crowns is very constant; they are formed with axes parallel to the sides of the hexagon, repeating constantly parallel to themselves and often taking on a feathery appearance.

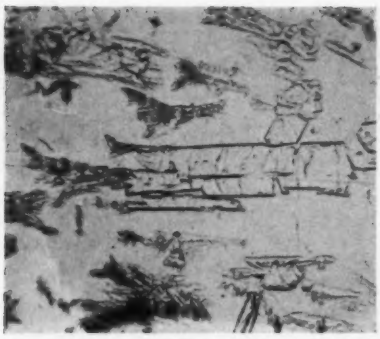
The ratio between the dimensions of the central plate and the total diameter of the crystal is very variable. In isolated crystals it sometimes happens that the dendritic crown is very much developed. An excellent instance is that shown in figure 4. Occasionally the central plate may even disappear, entirely hidden by more dendritic formations which thicken it and show above the overlapping dendritic surfaces. The appearance is then that of a regular prism of a snow white appearance, a little hollowed upon its bases (Fig. 6). In large crystallizations apparently made in a medium of less vis-

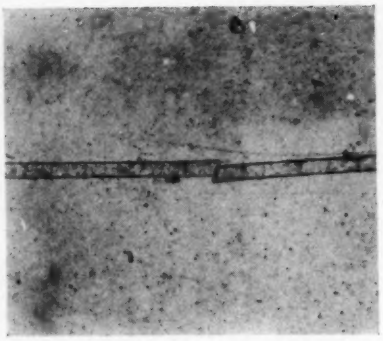






(left to right) Fig. 7. Large crystal with irregular contours from a window glass tank down for repairs. (×31 reflected light.) Fig. 6. Thick crystal in the form of a prism with hollowed bases. Fig. 8. Central part of a large crystal in tank glass. (×55 transmitted light.)





(left to right) Fig. 9. Crystal of complex formation from a window glass tank. (×62 transmitted light.) Fig. 10. Cross section of large plates with gaps in the growth. (×20 transmitted light.) Fig. 11. Cross section of part of a broken crystal formation in window glass tank. (×60 transmitted light.)

cosity, the platey part developes much more broadly, and the dendrites may almost totally disappear. At the same time, the external form is no longer always a perfect hexagon, but results frequently from the juxtaposition of a number of hexagonal forms (Fig. 7).

It is not certain that pseudowollastonite possesses any cleavages. Nevertheless there seems to exist in certain cases a faint basal cleavage, and perhaps another cleavage which would appear on the hexagon faces perpendicular to two opposite sides of the hexagon (indicated more or less in Fig. 5). In many cases the crystals, particularly the largest and thickest ones, show a tendency to an imbricated or overlapping structure, a result of the joining of elements of sub-hexagonal outline. This structure, more or less visible in figure 4, is shown in figure 8, which is a photograph of the central part of a large crystal. Figure 9 indicates, on a transverse section, a similar structure. The development of the crystal may even show gaps in its thickness. This is the case shown in figure 10. Apart from that, it sometimes happens that cross sections are divided by irregular cracks due probably to mechanical forces exerted after the formation of the crystals. This is undoubtedly true in some instances where the cross sections show fractures separating two fragments of a single crystal, or two fragments, one of which has been removed from its initial position (Fig. 11).

In certain rare instances I have observed groupings of two plates cutting each other along a diameter and forming between themselves an angle of about 60°. A cross section of such a grouping was illustrated in an earlier communication[8]. Very little is known about the crystallography of pseudowollastonite; in certain crystal formations I have announced the clear existence of a beveling around the plates. Such oblique terminations may be seen in Fig. 10.

The optical properties of pseudowollastonite are well known, and do not permit the mistaking of this material for any other of the bodies produced by the devitrification of soda-lime glasses. In ordinary light, the outline is heavily marked by the indices of refraction which are much higher than that of glass (mean index of crystal 1,630).

The double refraction is high (0.041) which gives to sections of pseudowollastonite examined between crossnicols, very clear and emphatic colors. The extinction of cross-sections is substantially straight and elongation negative. In cross-sections through the curved dendritic zones, the extinction varies from point to point; at any instant that part of the section is extinguished which lies tangential to one of the nicol axes. Sections in the plane of the hexagon are near thereto show little or no illumination between cross-nicols; on the other hand, in convergent light they show a black cross of a positive uniaxial crystal. At the edges of the crystal in the dendritic parts where the light passes through several more or less parallel layers, the black cross may still be observed but appears more hazy.

A more careful examination of cross-sections shows that the extinction is not always rigorously straight, and that there exist in certain crystals two laminae joined along the direction of elongation, and having extinctions

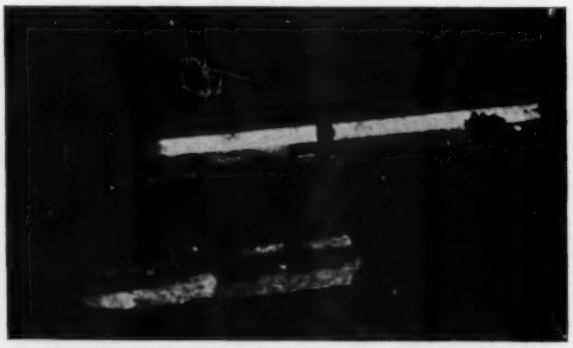


Fig. 12. Cross section of twinned plate. (×48 crossed nicols.)

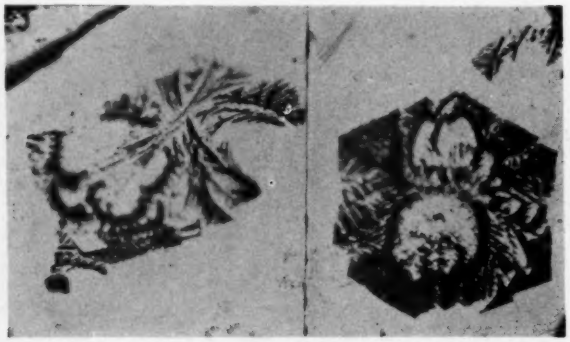


Fig. 13. Section through tangles of crystals. (×11 transmitted light.)

as a maximum of 6 degrees from one another, or say 3 degrees on either side of the twining plane, which therefore is parallel to the section elongation (Fig. 12).

It is a case of twining which may be poly-synthetic in rare instances. It would be similar to that of the micas and would indicate that pseudowollastonite is not hexagonal as it appears, but is really of a lower crystal symmetry. Moreover, close study of the black cross which basal sections give in convergent light sometimes show a trace of distortion of the center of the cross indicating the bi-axial nature. In the crystal the twining axis is sometimes outlined by inclusions of glassy groups.

The recognition of pseudowollastonite crystals by simple examination of a specimen is very easy. When they are isolated their form is characteristic and could hardly be approached, save by certain tridymite forms, from which pseudowollastonite may immediately be distinguished by the examination of a thin splinter of a specimen; the index is higher than that of glass, while that of tridymite is lower. Moreover, crystals of tridymite of a little larger size, examined flatwise, nearly always show an irregular network of fine cracks which is very characteristic. In massive crystallizations, one may meet with large plates where there may be seen the large rectilinear sections in the fracture (analogous to that of Fig. 10), or even meet with more compact crystallizations in white masses, apparently indistinct. But a more careful examination then shows at the peripheral parts, the forms of the crystals, while on the surface of the cracks one may observe with a magnifying glass numerous characteristic sections like a double "y", as in figure 3, or curved sections of confused dendritic plates (Fig. 13, right hand part).

Whether the crystallizing of pseudowollastonite is accompanied by a contraction or whether its coefficient of expansion is higher than that of glass, one may observe that the crystals frequently exercise a tension upon the surrounding glass. Examination in the polariscope of a small block quickly demonstrates these effects. Nonetheless, they are not sufficient to give a surface of separation around the crystals, such as one nearly always observes, for instance, around the formations of cristobalite. Nonetheless, these stresses could be the cause of certain cracks observed in the central parts of the crystals (Fig. 5.) On a cross-section these fractures show the same appearance as the well known microlites of apatite.

In the course of examining numerous examples of pseudowollastonite, I have never observed that the crystals of this material have served as nuclei for a later

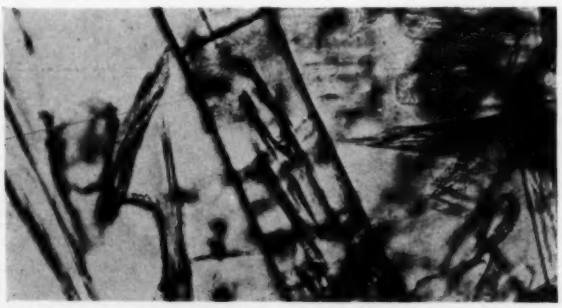


Fig. 14. Showing independence of the crystallizing of pseudowollastonite and other products of devitrification. (×85 transmitted light.)

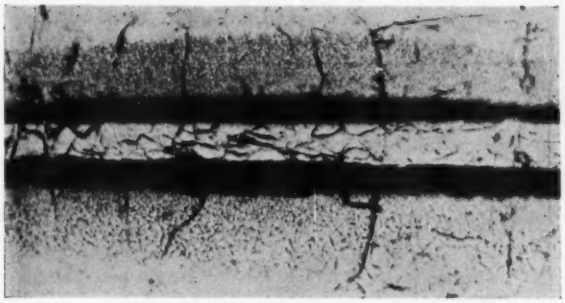


Fig. 15. Crystallizing of cristobalite in the neighborhood of a plate of pseudowollastonite. (×105 transmitted light.)

crystallizing of wollastonite or devitrite. Even in glasses containing an abundance of these latter compounds one can never recognize any relation between their development and that of pseudowollastonite.

A specimen of glass containing only a single crystal of pseudowollastonite a few millimeters in diameter was heated in a furnace to a temperature lower than that of the zone of stability of the pseudowollastonite. The glass was largely devitrified, giving wollastonite and devitrite, but these two materials developed without contact or relation with the pre-existing crystals, which remained unaltered. Figure 14 shows a part of the crystallization induced by such an experiment: the central crystal of pseudowollastonite has remained indifferent to the other crystal forms which are subsequent to it.

On the other hand, I have encountered a few rare instances of crystals of pseudowollastonite surrounded by microscopic crystals of cristobalite. It does not appear that in this case the lime silicate has served as a center of crystallization for the silica, but rather that the separation of the crystal of pseudowollastonite may have so modified the composition of the glass immediately adjoining, that, a little later on, the glass has thrown out silica with comparative ease. Figure 15 shows a case of this type. Small crystals of cristobalite are furthermore found between the fibers of certain devitrifications of wollastonite or of devitrite, where the presence is due to a similar cause.

I have been able to collect a few hexagonal crystals of pseudowollastonite which were devoloped around minute bubbles which thus served as centers of crystallization. In two other cases the same phenomenon was recognized around a tiny iron-bearing blemish.

[*] Presented at the first International Glass Congress at Milan, Sept. 1933. Translated for GLASS INDUSTRY by F. W. Preston, from *Verre et Silicates Industriels*, Vol. 5. No. 9, May 10, 1934.

[1] This name was proposed by Preston to designate the compound Na O. 3CaO, 6SiO, which frequently occurs in the devitrification of industrial glasses.

(Translator's Note: This footnote is not quite correct, and does me too much honor. The name was proposed by Morey and Bowen designating the crystal species, and the only part I had in the matter was urging upon them to give the thing a name, in order to save my time in writing out the formula.)

[2] H. Jebsen Marwedel, Kristalltrachten der technischen Kalk-Natron-Silikat-Entglasung und ihre Auslegung, Sprechsaal, 1929, Nos. 39 to 43.

[3] Le Chatelier, Bulletin de la Societe Francaise de Mineralogie, Vol. 39, p. 150.

[4] Journal de Physique, Sept. 1779, p. 187.

[5] M. Belliere, Des Cristaux hexagonaux trouvés dans du verre dévitrifié, "Annals of the Geological Society of Belgium," 1925, 47, p. 41.

[6] A. Dietzel, Die Kristallisations Geschwindigkeit der technischen Natron-Kalk-Silikatglaser, Sprechsaal, 1929, Numbers 28 to 36.

[7] Allen and White, Diopside and its relations to calcium and magnesium metasilicate. American Journal of Science, 27, January 1909, p. 92.

[8] Translator's Note: These figures differ slightly from those given in the Glastechnische Tabellen, where the crystal is described as pseudohexagonal monoclinic, and the indices are given: 1.610, 1.611, 1.654 double refraction therefore about 0.044.

[9] M. Belliere, loc. cit., plate fig. 4.

SUMMARY OF IMPORTANT DEFECTS AND THEIR DEPENDENCE ON TH

Kinds of Defects	BATCH	MELTING	FINING	STANDING
Stones, Knots	Poor Granulation. Insoluble Foreign Bodies. Lumping, as by Freezing.	Low temperature. Rapid Feeding of Raw Material. Corrosion of Refractories. Crown Droppings.	Too Rapid Current of Raw Batch. Unequal Solution of Refractories. Droppings of Furnace Glaze.	Formation of Devitrification-Sto esp. in Cooler Po Glaze Drops.
Cords	Poor Mixing. Segregation by Falling or in Transport. Unequal granulation. Lumping. Deficiency of Gas-Formers.	Insufficient Temperature or time. Glass too viscous for Heat-Conditions. Flowing apart upon melting. Dissolved Ref.	Rapid Temp. Drop. Dissolved Ref. Bad Floater-Behavior.	Irregular Heat-Distribution Precipitation. Local Attack on Refractories, as Rings, Floaters.
Seeds	Lack of Fining Agents. Unfavorable Gas Content. Unequal Granulation.	Low Temperature. Erratic Control of Temperature. Flow-Separation. Gas from Refractories. Irregular Feeding.	Low Temperature, Short Time, or Secondary Reactions. Viscous Glass. Furnace Atmosphere Trapped at Cold Surface.	Secondary Reactions Gas-Atmosphere. Rapid Cooling. Skin-Formation, Trapping Bubble Gas from Ref.
Devitrification				Deep Layers too Co Too long Time at Low Temp. Poor Composition. Dust, Splinters.
Bad Workmanship				
Breakage, Internal Strain.				
Surface-Clouding Decomposition.		Segregation. "Gall" Formation.	Protracted "Gall" Furnace Atmosphere. Flying Dust and ash.	Renewed "Gall". "Gall" formed by Furnace gases. Glass too Cool. Oxidizing Gases.

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SAFETY GLASS WILL FEATURE SPECIAL SALES CAMPAIGNS

Officials of the Libbey-Owens-Ford Glass Company, one of the world's largest manufacturers of safety plate glass, announced that they will back the special sales drive of the automobile producers with the biggest advertising campaign every put behind safety glass to "tell the world that safety glass all around is available at new low prices". The campaign will feature such themes as, "A car is no safer than the glass in its windows" and "Protection for those who Ride in the Back", it was announced. Dealers will be urged to make "safety glass all-around" an important part of their sales presentation to prospects.

The Libbey-Owens-Ford Glass Company has assigned specially trained men to give illustrated talks to dealers and their salesmen on the importance of emphasizing the need of safety glass protection in the windows and the new low prices at which it is now available. This special campaign to educate dealers and public on the value of safety glass all-around in new cars will be carried to every important distributing center in the United States.

ON THE STEPS OF GLASS MANUFACTURE (*ANON SPRECHSAAL, Vol. 67 No. 25*).

on of rification-Stones n Cooler Portions. rops.				
r Heat- bution ation. Attack on ctories, as , Floaters.	Thread-Formation. Irregular Heat-Distribution. Over-lapping. Burnt-in Oil. Action of Smoke. Solution of Ref.			
ıry Reactions. nosphere. Cooling. rmation, ping Bubbles. m Ref.	Bad Gathering. Trapped Air. Gassing of Coatings. Smoke, Oil, Rust. Effects of Working.			
ayers too Cold. g Time at Temp. mposition. olinters.	Time-Temperature-Ratio Wrong for the Glass. High Tendency of glass to Crystallize.	Held too Long at Upper Annealing Temp.		
	Bad Distribution of Heat or Glass. Wrong Viscosity. Stuck to Hot Mold. Mechanical Marking of Surface. Machine or Tool Defects.	Leer-melt. Wrong Adjustment. of Temperature. Glass too "soft".		
	Too Rapid Cooling—too "Hard" Glass. Bad Adjustment of Temperature to Thickness and Size. Mechanical Checks and Strains. Weakening by Grinding. Slow "Carry-in". Cold Mold.		Loose Packing. Residual Strain. Scratching. Poor Packing. Shock in Shipment. Car-Switching.	Heat-Shock, Shock, Fall, Pressure. Wear. Residual Strain. Strain from Various Causes.
ved "Gall". " formed by nace gases. too Cool. zing Gases.	Inclusion of Oil. Contact with Steam. Smoke. Dust and Dirt.	Reaction with Combustion-gases, as SO_2. Dust, Fused-in.	Poor Resistance. Condensation. Damp Storage. Wet Paper. Rain.	Attack by Water or Chemicals. Resistance too poor for intended purpose
STANDING **gress of the Glass**	WORKING	ANNEALING	PACKING, SHIPPING STORAGE	USE

FALL MEETING OF THE GLASS CONTAINER ASSOCIATION

The Fall Members Meeting of the Glass Container Association of America will be held at the Traymore Hotel, Atlantic City, N. J. on September 20 and 21.

The program for the meeting is tentatively set up as follows, with further announcement to be made later:

Wednesday, Sept. 19: Board of Directors Meeting Code Authority Meeting. Thursday, Sept. 20: Morning—General Session and Group Meetings. Afternoon—Golf Tournament.

Friday, Sept. 21: Glass Section and Group Meetings.

In order to provide ample time for discussion of Code and other industry problems and for group meetings, the program will be arranged differently than in the past. In place of the several Association departmental reports one written report covering all the Association activities will be prepared and summarized by Mr. Stevenson or Mr. Ackerman.

It is planned to have an official of the Federal Alcohol Tax Unit at the meeting to talk on the new Treasury Regulations and answer such questions as may develop.

ACTION OF SODIUM AMIDE ON SILICATES AND REFRACTORIES[1]

As sodium amide is very reactive and possesses a relatively low melting point (210°C) the investigators felt that it could advantageously be used to replace sodium hydroxide or carbonate in alkaline fusions of various silicates. In addition the use of expensive platinum crucibles could be eliminated as the sodium amide fusion is carried out in nickle crucibles.

The sodium amide used for the experimental work was prepared in a special muffle furnace by passing a stream of dry ammonia gas through molten sodium at a temperature around 350°C. The prepared salt was stored in bottles fitted with ground stoppers, greased at the top. The bottles contained an atmosphere of ammonia as a prevention against explosion.

The method of analysis used is as follows: the sample is ground with a mechanical grinding device to 200 mesh or finer and dried at a temperature of 110°C to 140°C. The fusion is carried out in 100-cc. nickel crucibles, with the use of approximately 20 grams of sodium amide and 0.5 gram of the silicate ore. Half of the sodium amide is first placed in the empty crucible, and the specimen for analysis is spread over its surface and then covered with the remainder of the amide. The 100-cc. crucible is placed within one of 150-cc. capacity to guard against the loss of material by the creeping of the fusion over the sides of the containing vessel. The two crucibles are then introduced into an electrically heated muffle furnace, previously heated to a temperature of 330°C. A stream of ammonia gas is passed through during the fusion and the subsequent cooling of the melts to room temperature. The fusion is carried out for 30 minutes in the case of materials such as feldspar, glasses or bauxite. Material of unknown behavior should be heated for 2 to 3 hours at 330°C. It is possible to avoid the use of a muffle, provided the inner crucible be fitted with a nickel cover carrying a nickel tube through which a slow stream of ammonia passes during the fusion.

The cooled inner nickel crucible and its contents (and also the outer crucible, if sodium amide has crept into it) are placed in a 500-cc. casserole, which is partly filled with 95 per cent alcohol and then covered with a watch glass. Small quantities of water are added from time to time as the reaction subsides. The subsequent analysis of the dissolved fusion is carried out according to the usual methods. Results of silica determinations on various silicates obtained by this method and the alkaline fusion method are shown in Table I.

[1] Abstracted from Ind. and Eng. Chem. Analy. Ed., Vol. 6, No. 2, p. 136, 1934. By P. V. Peterson and F. W. Bergstrom.

TABLE I. Comparison of Analysis by Sodium Amide and Conventional Alkaline Fusion Methods.

		Silicon Dioxide	
		Sodium amide method[a]	*Alkaline fusion method*[b]
Name	*Designation*		
Bauxite	B69[c]	6.4, 6.44[d]	6.32
Feldspar	B70	66.55, 66.59	66.66
Soda-lime glass	B80	73.9, 74.1	74.1
Glass Sand	B81	99.3, 99.3	99.26
Lead-Barium glass	B89	65.25, 65.39	65.4
Opal glass	B91	67.65, 67.65	67.6
Pyrex glass	...	80.2, 80.07	80.1
Burnt refractory	B76	54.7, 54.6	54.68
Burnt refractory	B77	32.34, 32.31	32.38
Czechoslovak clay	...	46.7, 46.6	46.9
Burnt refractory	B78	20.5, 20.63	20.69
Abestine	...	61.1, 61.0	61.0
Calamine	...	29.0, 28.9	29.0
Serpentine	...	35.4, 35.1	35.2
Soapstone	...	40.2, 40.2	40.26
Feldspar	...	65.7, 65.5	65.6
Soapstone	...	36.5, 36.5	36.6

[a] Fused 2 to 3 hours at 330°C., a time usually longer than necessary.
[b] Fused with sodium carbonate.
[c] Bureau of Standards standard sample No. 69 etc.
[d] Duplicate analyses of same specimen.

MOUNT VERNON FACTORY RESUMES

Operations at the Window Glass Factory of the Pittsburgh Plate Glass Company, Mt. Vernon, Ohio, are being resumed during the present month. The factory has been closed since December 1931. The starting of the plant puts 400 men to work and it relieves local unemployment to a great extent. Actual production of glass began August 15, and it is hoped that the improvement in business will be such as to warrant continuous operation.

CERAMIC CONFERENCE AT PENN STATE

"Colloidal Problems in Ceramics" will be the subject of a two-day conference to be held at Pennsylvania State College on October 5th and 6th. Among the papers which will be presented are the following:

1. "Progress in Soil Technology Resulting from Colloid Studies". Dr. Richard Bradfield, Professor of Agronomy, Ohio State University.
2. "Problems in the Utilization of Pennsylvania Fireclays". Dr. Fred Harvey, Director of Research, Harbison-Walker Refractories Company.
3. "Principles and Practice of Casting Refractory Shapes". Mr. Gordon Klein, Ceramic Engineer, New Castle Refractories Company.
4. "Fundamentals of Casting of Whiteware Bodies". Mr. T. A. Klinefelter, Ceramic Engineer, United States Bureau of Standards.
5. "Plastic Flow in Nearly Dry Clay Bodies". Mr. Harry Thiemecke, Homer-Laughlin China Company.
6. "Modern Methods for the Determination of Fine Particle Sizes". Mr. J. A. Wagner, U. S. Bureau of Standards.
7. "Metal Decoration for Ceramic Ware". Dr J. H. Young, du Pont de Nemours Company.

NOVEMBER GLASS CONFERENCE

The Department of Ceramic Engineering of the University of Illinois announces that in response to numerous requests, a second Conference on Problems of Glass Technology will be held in Urbana, Illinois, on Friday and Saturday, November 2 and November 3. As a side attraction, the football game between the Army and the University team is scheduled for the afternoon of the latter day.

FOREIGN TECHNICAL PAPERS

TRANSLATION By S. R. SCHOLES

SELENIUM-RED GLASSES*

Two varieties of selenium-red glasses are distinguished: selenium-rose, made with selenium alone, and selenium-ruby, obtained by the addition of cadmium.

I. Selenium Rose. Experiments were directed to determine (as in the pertinent researches of Springer) the upper limits of the quantity of selenium and its coloring power in rose; further, the difference between selenium and sodium selenite; and finally, the influence of arsenic and saltpeter. For these experiments soft lime glasses were made using sand 75, soda ash 30 (or potash 40), limestone 20. The lime was replaced in part or entirely by zinc oxide.

As to limit of color, it became evident that beyond a certain amount addition of selenium brought out no strengthening of color, at least not in the rose, but for the most part a yellow-brown. Elementary selenium, without added reagents, colored the glass more strongly than the equivalent—about double—weight of sodium selenite. With selenite, arsenic strengthened the color somewhat; on the contrary, arsenic weakened the color produced by elementary selenium. The potash-lime glasses were in general more rose-colored and also more strongly colored than the soda-glasses. Lime-zinc glasses exhibited a remarkably weak and only a yellowish-brown color in all cases. Saltpeter operated rather to strengthen the color from sodium selenite, while it destroyed the color when selenium was used.

Weckerle[1], in view of the published results of other investigators, has made a few melts with and without reducing agents, introducing the selenium as the sodium salt with the addition of sugar-carbon. Although several sorts of glass were melted, among them a glass rich in zinc from ordinary factory practice—see composition below—he never succeeded in getting anything but a brown color with the use of reducing agents. Only under neutral conditions was the glass rose; the zinc glass of the factory in spite of high amount of colorant was quite colorless. With the addition of arsenic the glasses were always rose-color. Further related experiments dealt with the volatilization of selenium under different melting conditions, which showed that under reduction, much higher amounts of selenium remain in the glass than do in neutral melts. The volatilization increased with higher temperature and increasing gas-content of the melt.

II. Selenium Ruby. We shall next discuss the experiments of Springer conducted with the same batches as previously. The soda-lime glass with sodium selenite, with and without arsenic, astonishingly enough, showed almost no color. Later trials showed that upon the addition of some charcoal the ruby color may also be obtained here. On the other hand, elementary selenium gave a strong ruby, while arsenic tended to destroy the color. It is still more remarkable that the potash-lime glass with the same additions was never ruby-red but only rose-color. The lime-zinc glasses or the pure zinc glasses behaved like the soda-lime glasses; that is, they assumed almost no color with sodium selenite but showed on the other hand with elementary selenium, a more or less strong ruby, always weakened by arsenic. Saltpeter had almost no influence upon the sodium selenite glasses, but with selenium, faded the color considerably toward yellow.

Weckerle made his experiments principally with the so-called factory glass as a basis. This corresponded to a batch of: sand 100, borax 11, limestone 13, zinc oxide 27, potash 36, soda ash 7, sodium selenite 3, and cadmium sulfide 2.5. In normal operation, this glass made a good ruby. It was found during the experimental meltings that the borax could be omitted without essentially changing the color. Complete substitution of potash by soda pushed the tint somewhat toward yellow. But substitution of the zinc oxide gave, in all cases, colorless or brownish glasses. If, for example, magnesia was put in for zinc oxide, the glass was colorless, also when lime replaced zinc oxide completely. All the trials with this glass lead to the conclusion that good color without zinc oxide is impossible. On the other hand, sodium selenite could be replaced by selenium without change. But an omission of the cadmium sulfide produced a colorless glass even when the cadmium was introduced as oxide. Therefore, it was attempted to supply the sulfur in elementary condition or as zinc sulfide, etc; but no coloration was obtained. In the latter case the glass was opaque-white. The foregoing experiments showed that besides selenium both zinc oxide and cadmium sulfide are necessary for a ruby glass. Further trials first lead to the conclusion that the cadmium sulfide can be replaced by the red cadmium selenide with omission of selenium. But to omit the zinc oxide in this case led to a negative result. A selenium ruby can therefore only be made, at least with the glass investigated, when the three constituents are present: zinc oxide, cadmium and selenium. Sulfur is therefore not necessary. The content of zinc oxide determines the amount of selenium present in the glass and with it the depth of color. Selenium can be introduced in various forms, the cadmium as sulfide or selenide.

These results of Weckerle's stand in apparent contradiction to those of Springer, who at least in soda-lime glasses, also without zinc oxide, obtained a good ruby glass; on the other hand, in potash-lime glasses, only with the addition of zinc oxide. Weckerle has repeated these experiments and confirmed the results.

Conclusion

Although one may not always carry laboratory results into plant practice without further ceremony, yet these test-melts can often give the factory man many indications as to what influence may be exerted on these delicate colors by alterations in the batch, change in colorants, or an addition or omission of certain oxidizing or reducing agents. Melts of bad color which appear to be riddles will thereby find clear explanation.

* From an article by L. S. Springer, Glashütte, 1934, 24, p. 400.
[1] Glastechn. Ber. 1933, No. 8 and 9.

ACCURACY OF MEASUREMENT AND NUMBER OF EXPERIMENTS

In Glashütte for June 25, K. H. Borchard presents a mathematical treatment of the problem of the variation of results in physical tests on glass. The particular set of data analyzed relate to hydrostatic breaking of bottles.

Representing individual values by l and the sum of n determinations by [l], he calculates an average value,

$$x = \frac{[l]}{n}. \qquad (1)$$

Variation of separate values from the average, the "apparent error", is found by,

$$v = x - l. \qquad (2)$$

The formula for the so-called "Mean error of the single measurement" reads,

$$m = \sqrt{\frac{[v^2]}{n-1}}, \qquad (3)$$

where brackets, [ ], again denote summation. The root of the quadratic is of course positive or negative, as the original single measurement was high or low. The denominator must be n-1 and not n, because a single measurement allows no conclusion as to accuracy. The error, m, denotes the degree of reliability any single measurement deserves.

The relative certainty of the mean value x is indicated by the so-called "mean error of the mean value",

$$m_x = \frac{m}{\sqrt{n}},$$

where m is derived by formula (3). This is an expression of the increase of accuracy with the number of experiments.

An example is made of an actual series of 14 bursting-strength tests of bottles, giving results from 23 to 33 Atm. [l] = 385. The values of [v] show + 19 and —19, or [v] = o, a condition requisite to accurate calculation. $[v^2] = 146$.

$$x = \frac{[l]}{n} = 27.5$$

$$m = \sqrt{\frac{[v^2]}{n-1}} = \sqrt{\frac{146}{13}} = \text{about } 3.35$$

The per cent error becomes $\frac{m}{x} \times 100 = 12.2$ per cent.

The mean error of the mean value is

$$\frac{m}{\sqrt{n}} = \frac{3.35}{\sqrt{14}} = \text{about } .9$$

The accepted result is therefore

$$x = 27.5 \pm .9 \text{ Atm.}$$

The graph of mean error plotted against number of determinations if of course hyperbolic in form. This brings out the fact that after a reasonable number of trials, say 15 to 20, the accuracy is only slightly improved by a greater number, and the question becomes one of economy.

GLASS DIVISION MEETS SEPTEMBER 14-15.

The Glass Division of the American Ceramic Society will meet at Hammondsport, New York, on September 14 and 15. The program, starting at 9:30 A. M. has been planned as a symposium on the chemical durability and corrosion resistance of glass. The following papers will be presented.

September 14th

I. "The Corrosion of Glass as a problem in its Manufacture, Distribution and Service."

Flat Glass: W. F. Brown, Libbey-Owens-Ford Glass Co.

Glass Containers: F. C. Flint, Hazel-Atlas Glass Co.

Miscellaneous Glass Products: W. C. Taylor, Corning Glass Works.

II. Methods of Determining the Chemical Durability of Glass.

"Chemical Durability of Glass and Methods for its Measurement." Geo. S. Morey, Geophysical Laboratory.

"The Time Factor in Tests of the Chemical Durability of Glass." D. E. Sharp, Bailey & Sharp Co.

"The Measurement of the Chemical Durability of Flat Glass." J. S. Gregorious, Pittsburgh Plate Glass Co.

"Methods for Determining the Chemical Durability of Soda-Lime Glasses." O. G. Burch, Owens-Illinois Glass Co.

"Methods for Determining Special Types of Chemical Durability." W. C. Taylor, Corning Glass Works.

"Surface Electrical Properties of Glass in Relation to Chemical Durability." E. M. Guyer, Corning Glass Works.

September 15th

"A Proposed Standard Test for the Determination of the Chemical Durability of Glass."

"Chemical Durability of Glass Bottles." Mr. M. Parkin, Sheffield, England.

"Summary and Future Program." J. C. Hostetter, Corning Glass Works.

Luncheon talk by F. M. Champlin on the Chemistry of Wines.

Visit to Pleasant Valley and Urbania Wine Cellars.

Boat races back to Hammondsport. Golf at Penn Yan and Watkins Glen. Shore Dinner at Willow Point.

September 16th

Boat trips around the lake. Dinner to be arranged.

The Glass Division had expected Professor W. E. S. Turner would be present to read a paper on "Chemical Durability of Glass Containers" and to take part in the general discussions, in which his extensive experience would have proved most helpful. Professor Turner's health, however, will not permit him to take the long voyage from England, and Mr. M. Parkin will come as his representative.

DIAMOND GLASS CO. REORGANIZES

The Diamond Glass Company, Royersford, Pa., has recently been reorganized, and is now under the direction of the following officers. Frank B. Foster, President and Treasurer; H. R. Macturk, Vice-President and General Manager; M. L. Latshaw, Secretary; Frank B. Foster, Jr., Ass't. Treasurer; John H. Foster, Ass't. Secretary. Mr. Macturk was formerly associated with the Salem Glass Company.

THE DURABILITY OF GLASS
—a Bibliography of the Important Literature

EDITOR'S NOTE.—This month the Glass Division will hold a symposium on the Chemical Durability and Corrosion Resistance of Glass. As a contribution to the general subject, THE GLASS INDUSTRY has had compiled a bibliography of all the important literature that has appeared since 1900. For convenient reference, an attempt has been made to group these papers into five main divisions; however, the scope of some papers is broader than the subject classification. The first three of these divisions, found below, include: Weathering, Tests and Methods of Testing, and Action of Chemicals and Water on Glass. The remaining two divisions will be given in the October number.

I. The Weathering of Glass

The Dulling of Window Glass. M. Stoermer, (Sprechsaal, 1901, 34, 1173).
Compositions of window glass suitable for improving the resistance to weathering are given.

The Weathering Properties of Heavy Glass. F. Mylius. (Zeitsch, anorg. Chem. 1907, 55, 233, 1910, 67, 200).

The Filming of Glass. (Trans. Optical Soc., 1918, 19, 184).
A discussion of weathering of optical glass, and effect of lubricants used in optical instruments.

Exhibit of Samples of Glass Showing Filming. W. H. Withey. (Trans. Opt., Soc., 1918, 20, 40).

The Examination of Optical Glass in Relation to Weathering Properties. A. Y. Eldsen, O. Roberts and H. S. Jones. (J. Soc. Glass Tech., 1919, 3, 52).
A description of weathering and methods for testing resistance. Iodoesin and "Dimming Test" outlined. Results of tests using these methods and glass compositions given.

Note on the Mechanics of the Weathering of Glass. F. R. von Bichowsky. (J. Amer. Cer. Soc., 1920, 3, 309).
A discussion of a theory of the action of water on glass.

A Practical Test for the Resistance of Optical Glass to Weathering. F. R. von Bichowsky. (J. Amer. Cer. Soc., 1920, 3, 296).
Details of a modified iodoesin test and an autoclave test using water, 1.1 HCl and 5 per cent solution of NaOH.

Durability of Optical Glasses. (Report of the British Scientific Inst. Research Assn. 1921).
A discussion of weathering, methods of test and the results of various tests.

The Resistance of Glasses to Attack by Water. G. Keppeler. (Beitrage zur Metal. Goldschmidt-festschrift p. 40 Dresden, 1921).

The Weathering of Glass Containers. K. L. Ford. (J. Amer. Cer. Soc., 1922, 5, 837).
Microscopic examination of weathered surfaces were made and graded into three classes. Chemical analysis of products of weathering given. Discussion of methods of packing containers to retard weathering.

Glass Containers—A Discussion. (J. Amer. Cer. Soc. Bull., 1922, 1, 343).
Contains a discussion on the weathering of glass.

The Susceptibility of Optical Glasses to Staining. W. Tepohl. (Glastech. Ber., 1923, 1, 97).
The action of water and acid solutions on optical glasses studied.

The Weathering of Bulb Glasses. S. Takahashi. (J. Jap. Cer. Assoc., 1924, 32, 373).

The Tarnishing of Optical Glasses. H. Heinrichs and W. Tepohl. (Glastech. Ber., 1925, 6, 213).
A discussion of various tests.

Storage Effects on Sheet Glass. Anon. (Sprechsaal 1926, 59. 156).
A discussion of the development of weathering by various methods of storage.

On the Tarnishing of Optical Glasses. H. Heinrichs. (Z. Inst., 1926, 46, 424).
A discussion of results obtained by determining the material extracted by acetic acid solution after 1 hr. boiling.

The Weathering of Glasses. K. Tabata, K. Yegami and S. Moriyasu. (Researchs of the Electrotech. Lab., Tokyo, 1926, No. 179).

The Weathering of Glass. K. Kubl. (Glashutte, 1927, 57. 767).
A discussion of the causes of weathering.

The Formation of Films of PbS on Glass Surfaces. H. L. Smith. (J. Sci. Inst., 1927, 4, 115).

Relation Between Weathering of Glass and the Relative Humidity. (Preliminary Report). K. Tabata. (J. Soc. Chem. Ind., Japan, 1928, 31, 60B).

Surface Changes and Deposits on Glass. F. H. Zschacke. (Glashutte, 1930, 60, 367).
A review of weathering.

The Weathering of Plate Glass. H. Hermann. (Keram. Rundschau, 1930, 38, 653).
A study of the action of moisture and carbon dioxide on plate glass after packing.

Effect of Certain Oils in Emphasizing the Weathering of Glass. P. Woog. (Bull. Soc. Chim., (France) 1930, 47-48, (IV) 450).

Weathering Dangers with Sheet Glass. H. Hermann. (Sprechsaal, 1931, 64, 375).
Wooden crates used for packing are source of water which causes weathering during transit and storage.

Tropical Durability of Glass. W. Tepohl. (Glass und App., 1931, 12, 610).
A discussion of the influence of tropical climates on the weathering of glass.

Risk of Weathering of Plate Glass. Anon. (Sprechsaal, 1931, 64, 167).

The Weathering and Iridescence of Some Ancient Roman Glass. S. W. Lanbengayer (J. Amer. Ceram. Soc., 1931, 14, 833).

On the Resistance of Glass to Weathering. H. Hermann. (Sprechsaal, 1932, 65, 45).
General discussion on weathering and methods for retarding.

The Double Carbonates of Sodium and Calcium as Weathering Products of Soda-Lime Glasses. A. Dietzel. (Sprechsaal, 1932, 65, 825-826).

The products of weathering were found to be double carbonates of sodium and calcium. Discusses the weathering of glass in hot climates.

II. Tests and Methods of Testing Durability

Some Methods of Testing the Durability of Optical Glass. E. Zschimmer. (Deut. Mech. Zeitung, 1903, 53).
A description of the weathering of glass and methods of testing the relative resistance to weathering.

The Electrochemical Determination of the Attack on Glass. F. Haber and H. Schwenke. (Zeitsch. Elektrochem. 1904, 10, 143).
The action of water on glass was measured by the conductivity method. Proposed as a method for measuring durability.

Bottle Glass and Glass Bottle Manufacture. W. E. S. Turner. (Jour. Soc. Glas. Tech., 1919, 3, 37).
Contains a discussion of methods for improving durability of bottles and descriptions of various durability tests especial for medicine bottles. Colormetric and precipitation tests are proposed in addition to a test using water at 120°C for 2 hrs. Contents of bottles titrated with N/100 H_2SO_4 using methyl orange.

The Selection of Glass for the Manufacture of Ampoles. G. C. Ewe. (J. Franklin Inst., 1920, 189, 649).
Results of durability tests on glass tubing are given. Following specifications are given, glass should not yield alkali or spicules during sterilization of pharmaceutical preparations; 1 per cent solution of morphine sulphate or a normal saline solution containing 0.2 per cent of strychine sulphate should not become turbid when sterilized in ampoles which had been washed with dilute HCl and water. Sterilization of a 0.6 per cent solution of NaCl should not yield spicules.

Tests for Laboratory Resistance Glassware. Anon. (J. Inst. Chem., 1920, 3, 202).
Specifications and methods for testing durability of chemical glassware.

An Autoclave Test for Grading Chemical Glassware. W. L. Baille and T. E. Wilson. (J. Soc. Chem. Ind., 1922, 41, 45T).
A description of methods and specifications.

Some Aspects of the Autoclave Test for Testing the Durability of Glass. W. L. Baille. (J. Soc. Glass Tech., 1922, 6 279).
A discussion of methods of testing by the autoclave and results of tests.

Some Criticisms on the Use of the Autoclave as a Method of Testing Glassware. W. H. Whithey. (J. Soc. Glass Tech., 1922, 6, 289).
A discussion of the variable results obtained by the autoclave method.

Specifications and Standard Methods for Testing Lime-Flint Glass. A. E. Williams. (Glass Ind., 1922, 3, 47).
Contains specifications and methods of conducting a boiling test for glass tumblers for resistance to spalling.

A Critical Examingation of Methods Commonly used in Determining the Durability of Glass. W. E. S. Turner. (J. Soc. Glass Tech., 1922, 6, 30).
Contains a discussion on the expression of results by loss in weight; alkali extracted; total material extracted. A discussion of the autoclave method, glass surface, glass plate and powder methods. Following tests were proposed as standards: 1. Plate or disc, 80 to 100 sq. cm. treated with water or HCl for 6 hrs. at 100°C or alkaline solutions for 3 hrs. at 100°C. Volume of solution kept constant at 500 cc. 2. Powdered glass, 20-30 mesh, dust free. 10 grams in 500 cc. of solution at 100°C. Loss in weight method or total alkali extracted used for works laboratory test. Total matter extracted used for precision test. Powder test is recommended.

A Rapid Method of Testing the Durability of Glassware. H. S. Blackmore, V. Dimbleby and W. E. S. Turner. (J. Soc. Glass Tech., 1923, 7, 122).
A recommendation of the narcotine hydrochloride test. Details and specifications are given along with results of tests on bottles of known compositions.

Tests on the Resistive Qualities of Soda-Lime Glasses to Water. L. A. Palmer. (J. Amer. Cer. Soc., 1923, 6, 579).
The action of boiling water for 6 hrs. on bottles and tumblers was investigated. Results compared with the calculated durability using Baille's modification of the Zulkowski formula.

Specifications in the Glass Industry. W. E. S. Turner. (J. Soc. Glass Tech., 1924, 8, 3).
Contains a discussion on durability.

A Simple Weathering Test for Glass. F. Spate. (Glastech. Ber., 1925, 4, 127).
Samples were exposed to an atmosphere of carbon dioxide saturated with water vapor.

Appearance of the Surface of Neutral Glasses after Tests in the Autoclave. A. Mauri. (G. Chim. Ind. App., 1925, 7, 452).
A review of previous work, results of authors tests, comparison with results of other investigations and a discussion of the subject.

The Durability of Medical Glasses and the Testing Thereof. E. Urbschat. (Keram. Rundschau, 1925, 33, 812, 829).

Testing Glass Vessels According to the German Pharmacoepia 6th Ed. L. Kroeber. (Apoth. Ztg., 1926, 41, 1406).
A discussion of the narcotine hydrochloride and the methyl red tests.

The Estimation of the Soluble Alkali from Glass. E. Fisher and W. Tepohl. (Glastech. Ber., 1926, 4, 137).
The following method was used: 1cc. of well washed glass grains between 0.3 and 0.15 mm. sieve treated in 50 cc. of water for 3 hr. at 80°C. 25 cc. of solution titrated with N/100 HCl using iodoesin or methyl red indicator. Results calculated to 50 cc. and recorded as mg/1000 Na_2O per cm^3. Results compared with Mylius method.

Baroni Reaction for Neutral Glass for Pharmaceutical Purposes. L. Tirelli. (Boll. chim. farm., 1926, 65, 65).
A discussion of the factors affecting the following test: Tubes filled with water and sealed in the flame. Steamed at 2 atmospheres for 1 hr. Cooled and opened. Solution treated with a 1 per cent alcoholic solution of crystalline haematatoxylin. No pink or violet blue color should develop in 24 hrs.

The Iodoesin Test on Powdered Glass. W. Mylius. (Sprechsaal, 1926, 59, 327).
An outline of a method using the iodoesin test on powdered glass and the results of tests on various glasses.

A Simple Method for Determining the Chemical Resistance of Glass. F. Friedrichs. Z. Angew. Chem., 1926).
The piece of glass is heated in boiling water for 12 hrs., removed and heated to softening point. Surface of poor glasses are covered with fine lines.

The Chemical Testing of Glasses. F. Spate. (Berichte der Fachauschusse, 1926, 3, 1).
Contains a study of various durability methods, a recommendation of methods for various glasses. Also contains a bibliography of durability methods.

A Simple Test on the Disintegration of Glasses by Atmospheric Agents. F. Spate. (Le Verre, 1927, 7, 1).
Samples were exposed to atmosphere of CO2 (dry or humid) at elevated temperatures for several days. The resistance determined by the debris on the surface; determination of the alkali content of the debris after solution in water or by determination of total matter dissolved off by the surface by water or acid.

Critical Observations on the Directions for Glass Testing of the German Pharmacoepia 6th Ed. L. Kroeber. Sprechsaal, 1927, 20, 356).
A criticism of the following tests: (a) medical glasses filled three quarters with aqueous solution containing 1 cc. of N/100 HCl per liter and 5 drops methyl red solution and heated for 0.5 hr. at 100°C. The red color should not have completely disappeared. (b) Ampole glass for solutions of alkaloid solutions: 5g. of coarsely crushed sample is heated at 100°C for 0.5 hr. in 100 cc. water containing 0.3 cc. N/100 HCl and 1 drop of methyl red. The red color should not disappear. The author recommends the narcotine hydrochloride.

PH Value and the Apparent Neutrality of Certain Bottle Glasses. (Keram. Rundschau, 1928, 36, 328).

The Determination of the Durability of Glass by the Powder Method. M. Thomas. (J. Soc. Glass Tech. 1928, 12, 47, 87).
A discussion of various powder methods.

The Estimation of the Alkali Dissolved from Ground Glass. E. Fisher and W. Tepohl (Sprechsaal, 1928, 61, 847).
A description of the following method: two grams glass grains between 0.3 and 0.49 mm. in diameter treated in a 50 cc. graduated flask with 50 cc. of water at 100°C for 1 hr. Contents of flask titrated with N/100 HCl using methyl red. A back titration method is also given.

On the Determination of the Solubility of Glasses by the Powder Method. E. Fisher and W. Tepohl. (Glastech. Ber., 1928, 9, 532).
The method of the Committee of the Deutsche Glastechnische Gesellschaft used on twenty glasses. The method was as follows: (sp. gr. x 4) gram of glass powder (0.3 to 0.49 mm. grain size) washed free of dust with water or alcohol. Boiled at 100°C. with water (100 cc.) under a reflux condensor. 75 cc. of the filtered liquid evaporated and dryed to constant weight at 150°C. Results calculated to 1000 cc. and compared with results obtained by the F. Mylius classification.

The German Pharmacoepia Method of Testing Medical Glasses. W. Mylius. (Keram. Rundschau, 1928, 52, 22).
A discussion and criticism of the tests.

A Radioactive Method for Testing the Properties of Glasses. O. Hahn and H. Muller. (Glastech. Ber., 1929-30, 7, 380).
A discussion of an emanation method for determining durability.

The Physical and Chemical Analysis of Materials used in Medical Services. F. Lewis-Smith and F. Hooper. (U. K. 5th Inter. Cong. of Military Medicine and Pharmacy, London, May 1929).
A review of methods for testing containers for hypodermic solutions and medicines.

Report on the Chemical Durability of Glasses. Anon. (Glastech. Ber., 1929, 6, 635).
A discussion on the difficulties in choosing suitable methods for testing weathering and chemical resistant properties of glasses. Procedures chosen by the committee given in detail.

Contribution on the Testing of Glasses for Chemical Durability. L. Springer. (Sprechsaal, 1929, 62, 187, 206).
The results of storage tests and leaching tests at 80°C. are given. It was concluded that laboratory tests were not sufficient to judge the weathering properties of a glass.

The Manufacture and Properties of Glass and their Application in Illuminating Engineering (Chemical Durability). S. English. (Illum. Eng., 1929, 22, 136).
A modified powder method using a special extraction apparatus described. Glass boiled in water for 1 hr. solution titrated hot with N/20 H_2SO_4 using brom-thymol-blue indicator. Results calculated to Na20. The Na20 reciprocal termed "Figure of Merit".

The Properties and Testing of Ampole Glasses. W. Tepohl. (Glastech. Ber., 1929-30, 8, 82).
A description of the specifications and the testing of ampole glasses.

A Critical Investigation of Methods for Determining the Durability of Glass. E. Rexer. (Keram. Rundschau, 1930, 38, 387, et. seq.).
A critical discussion of various methods using water.

Testing of Resistance Glass Ampoles. J. Pritchard. (Pharm. J., 1930, 124, 539).
Description of a change in pH method.

The Solubility of a Bottle Glass in Water as a Function of Time and Temperature. C. Schmid. (Sprechsaal, 1930, 63, 759).
Using a conductivity method the action of time and temperature on a glass of known composition was investigated.

A Standard Test and Specifications for the Chemical Durability of 4 oz. Flat Medicine Bottles. (J. Soc. Glass Tech., 1931, 15, 58, 52).
A description of a standard test, procedure and specification for a 4 oz. flat medicine bottle. The bottles are filled with water and heated in steam (100°C=) for five hours in a special boiler. Contents titrated. Satisfactory ware will not give up more than 5 mg. of alkali as Na20.

Proposals for a Standard Test on Ampole Glass. (J. Soc. Glass Tech., 1931, 16, 59).
A discussion and results of various tests.

Limits to be Prescribed for the Hydrolytic Durability of Apparatus Glass. F. H. Zschake. (Chem. Ztg., 1931, 55, 580).
A discussion of various powder tests and test limits for various glasses.

Influence of Temperature on Durability of Glass to Water. W. Tepohl. (Glastech. Ber., 1931, 9, 390).
It was stated that results obtained at one temperature of test were not sufficient to enable the prediction of the probable behavior at another test. Temperature of test should be that allied with the use to which the glass was to be put. Effect of change of temperature on the results is not the same for all glasses. A description of results obtained on various glasses at different temperatures were given.

The Effect of Temperature on the Alkalinity of Glass Surfaces. G. Keppeler and M. Hecktor. (Glastech. Ber., 1932, 10, 37-40).
A sample of glass tubing was heated for periods of 1; 2; 4 and 7 hrs. at temperature of 450; 500; 550 and 575° C. The alkalinity as measured by the Mylius method was observed to increase with rise in temperature and increase in time.

The Testing of Ampole Glasses in Practice. E. Ubrig. (Pharm. Ztg., 1932, 77, 227).
Review of tests for ampole glasses.

The Chemical Testing of the Surface of Sheet Glass. H. Jebsen-Marwedel and A. Becker. (Glastech. Ber., 1932, 10, 556-559).
A description of an apparatus and a method for determining the durability of the surface of sheet glass.

Test for the Chemical Resistance of Glass Containers. F. C. Flint and A. K. Lyle. (Bull. Amer. Ceram. Soc., 1933, 12, 296-299).
Bottles were filled with distilled water and autoclaved at 35# for 6 hrs. Contents titrated with N/10HCl using methyl red indicator. Results calculated to grams NaOH per liter.

The Relation between Time and the Attack of Water on Glass. G. Keppeler and M. Thomas-Welzon (Glastech. Ber., 1933, 11, 205-208).

The Testing of Medical Glasses. F. H. Zschacke. (Sprechsaal, 1933, 66, 456-458).
A discussion of certain objections to the narcotine hydrochloric test.

Report of the Meetings of Technical Committees of the D. G. C. in Berlin. (Jan. 19, 1933) F. Spate. (Glastech. Ber.).
Contains a report on testing of glass by the powder method.

Testing Medical Glasses. E. Tienier. (Sprechsaal, 1933, 66, 560-561); W. Tepohl. (Sprechsaal, 1933, 66, 541, 42); L. Kroeber. (Sprechsaal, 1933, 66, 576).
Replies to the criticism of F. H. Zschacke to the narcotine hydrochloride test.

The Testing of Ampole Glasses. G. Dultz. (Pharm. Ztg., 1933, 78, 482-483).
A discussion of errors due to the variation of capacity of the ampoles.

III. The Action of Chemicals and Water on Glass

Glass for Water Gauge Tubes. F. Krull. (Zeitsch. angrew. Chem. 1902 [xiii], 309).

Action of Phosphoric Acid on Silica and Silicate Glasses. K. Huttner, (Zeitsch. anorg. Chem. 1908, 59, 216).

The Action of Alkalies on Glass. F. Jones (Mem. Manchester Lit. Phil. Soc., 1902, 47, 1).
Results of investigations on the action of lime and baryta water on green glass bottles.

The Resistance of Chemical Glassware. P. Nicolardot (Compt. rend., 1916, 163, 355).

Comparative Tests of Chemical Glassware. Walker and Smither. (J. Ind. Eng. Chem., 1917, 9, 1090).
The loss of weight of beakers and flasks upon treatment with various reagents determined. Composition of glasses used given.

The Attack of Chemical Reagents on Glass Surfaces, and a Comparison of Different Types of Chemical Glassware. J. D. Cauwood, S. English and W. E. S. Turner (J. Soc. Glass Tech., 1917, 1, 153).
A discussion of the need of chemically resistant glass, the degree of resistance needed for various uses, and a description of various methods of testing durability. Results of investigations on the attack of various chemical glassware by different reagents are given along with a discussion of the results, the relative value of the tests, and the chemical factors which make for stability. Glass compositions are given.

The Effect of the Continued Action on Chemical Glassware of Water, Acid, and Alkalies. J. D. Cauwood and W. E. S. Turner (J. Soc. Glass Tech., 1918, 2, 235).
Results of successive tests on flasks by various reagents given. Sodium calcium glasses obtained a more resistant surface by continued treatment with water or acid. Borosilicate glasses improved slightly with water but not affected by acid. None of the glasses improved with continued action of the alkalies.

The Effect of Temperature on the Rate of Corrosion of Glass J. D. Cauwood and W. E. S. Turner (J. Soc. Glass Tech., 1918, 2, 260).
Results show that corrosion rapidly increases with temperature. Rate of increase with temperature is less with hydrochloric acid than water or alkalies.

The Resistant Properties of Some Types of Foreign Chemical Glassware. J. D. Cauwood and W. E. S. Turner (J. Soc. Glass Tech., 1918, 2, 219).

Further Investigations on Chemical Glassware. C. Muirhead and W. E. S. Turner. (J. Soc. Glass Tech., 1919, 3, 129).

The Reactivity of Powdered Glasses. P. Nicolardot. (Compt. rend., 1919, 169, 335).
The relative value of chemical glassware determined by the powder method.

The Distintergration of Soda-Lime Glasses in Water.. A. G. Williams. (J. American Cer. Soc., 1922, 5, 504).
Results of investigations of the action of Water below, at and above the boiling point on glass articles of soda-lime glass are given. Discussion of spalling and relation to durability and condition of glass surface.

Action of Water and Steam Under Pressure on Some Soda-Lime Glasses. F. H. Hodkin and W. E. S. Turner. (J. Soc. Glass Tech., 1922, 6, 24, 291).
Results of experiments on glasses of known compositions given. Discussions on the use of the autoclave for durability testing.

Action of Various Analytical Reagents on Chemical Glassware. W. E. S. Turner and T. E. Wilson. (J. Soc. Glass Tech., 1922, 6, 17).

Contamination of Water Samples With Material Dissolved from Glass Containers. W. D. Collins and H. B. Riffenburg. (J. Ind. Eng. Chem., 1923, 15, 48).
Description of changes in water stored in poor and good bottles.

The Action of Potassium Carbonate on Lead Glass. H. D. Richmond. (Analyst, 1923, 48, 260).
Analysis of potassium carbonate after storage in a lead glass showed presence of lead.

Note on the Action of Potassium Carbonate on Lead Glass. E. A. Coad-Pryor. (J. Soc. Chem. Ind., 1924, 43, 27T).

A Comparative Study of Laboratory Glass Made in France, England, Germany and Austria. P. Nicolardot. (Chim. et Ind., 1923, 9, 233, 469).
Results of investigations of the action of various reagents on chemical glasses. Glass compositions given.

The Chemical Resistance of Laboratory Glasses. A. Mauri. (Giorn. Chim. Ind. App., 1923, 5, 495).
The action of various reagents on several chemical glasses.

Chemical Resistance of Laboratory Glasses. A. Mauri. (Atti. Congr. Naz. Chim. Ind., 1924, 330).

Absorption of Water Vapor by Glass Surfaces D'Huart. (Compt. rend. 1925, 180, 1594).

The Resistance of Some Chemical Glasses to Chemical Reagents. D. Migliacci. (Ann. Chim. Applicata, 1925, 15, 8).

The Sensitiveness of Some Kinds of Glass to the Action of Chemical Reagents. E. E. Klamer. (Chem. Weekblad, 1925, 22, 140).

The Resistance of Glass to Chemical Attack. B. P. Dudding and W. Singleton. (J. Soc. Glass Tech., 1926, 10, 358).
A diagramatic collection of results of tests on various glasses.

Chemical Resistance of Glasses. G. Keppeler. (Glastech. Ber., 1927, 3, 97).
A graphical representation of the relationship between composition and durability of soda-calcium-silica glasses with and without alumina. Effect of annealing and flame gases during annealing investigated.

The Decomposition of Glass by Water at High Temperatures. G. W. Morey and N. L. Bowen. (J. Soc. Glass Tech., 1927, 11, 97).
A study of the crystalline products formed by the reaction of water with various glasses at temperatures of 300 to 550°C.

A Contribution on Solubility of Glass in Water. P. Tietze. (Sprechsaal 1927, 60, 813).
Glass grains 0.07—0.08 mm. treated with 100 cc of water at 100°C for various periods. Durability curves drawn and results discussed.

The Behavior of Glass to Saturated Steam. F. Friedrichs. (Sprechsaal, 1928, 61, 282).
Results of investigations on the effect of time and temperature of glasses treated in autoclave. Temperatures: 150° to 360°C; Times: 1 hr. to 24 hr. Alkali extracted and loss in weight used as measure of durability.

On the Behavior of Glass Towards Some Aqueous Alkali Solutions. F. Friedrichs. (Sprechsaal, 1928, 36, 713).
Results of investigations on resistance of glass to alkali solution using an autoclave at temperature of 100 to 300°C. Loss in weight and alkali extracted (titration with N/1 HCl using methyl orange) used as a measure of durability. Results are discussed.

Note on the Effect of Reaction Time and Concentration of Alkali Solutions on the Durability of Glass. M. A. Besborodow. (Glashutte, 1928, 58, 957).

Annealing and "Extraction Values for Chemical Apparatus Glass". H. Lober. (Sprechsaal, 1928, 61, 18).
The influence of several successive annealings on alkali extracted is discussed.

The Behavior of Glasses Towards Sodium Hydroxide Solutions at High Temperatures. F. Friedrichs. (Sprechsaal, 1928, 61, 967).
A study of the action of normal sodium hydroxide solution in the temperature range of 78° to 298°C on various glasses.

The Theoretical Basis of the Durability of Glasses. P. Tietze. (Sprechsaal, 1928, 61, 809).
Contains a theoretical discussion of the action of water and alkalies, and the rate of reaction. Curves showing the rate of reaction of various glasses with water are given and the method used described.

The Relation Between the Resistance of Glass to Alkalies and Acids and the Concentration in H-ions. O. K. Botwinken and A. M. Tanchilewitsch. (Z. anorg. Chem., 1928, 168, 356).
Results are given of the attack of various strength solutions of HCl and KOH on bottle and window glass in powdered form, using 10g. of glass powder, (20 and 30 opening per sq. in.) four hours at room temperature, in a well stirred solution. Loss in weight used as a measure of resistance. The results showed that the attack on the glass increased with the concentration of the OH ions for the alkaline solutions but was practically independent of the H-ion concentration for the acid solutions.

The Solubility of R2O.PbO.SiO2 Glasses in Water (I) K. Tabata and K. Yegami. (Researches of Electrotech. Lab. 1928, No. 270).
The solubility of χ K_2O (1-χ) Na_2O; 0.25 PbO, y SiO_2 glasses in water at 30°C were measured by the "H" electrode method.

Comparative Tests on the Durability of Russian and Foreign Laboratory Glasses. M. A. Besborodow. (Keram. Rundschau, 1929, 8, 121).

Alkali Content of Medicinal Glasses. B. Schwenke. (Pharm. Ztg., 1929, 74, 261).

The Durability Towards Water of Domestic Pressed Ware. C. A. Becker and C. Kraft. (Sprechsaal, 1929, 16, 261).
Results are given of solubility tests using standard powder method of E. Fisher and Tepohl and a rapid method consisting of 2g. of well washed glass grains between 20 and 12 mesh (D.I.M.1171) sieves boiled for 1 hr. in 50 cc of water. Titrated with N/100 HCl using methyl red.

The Solubility of the R2O.PbO.SiO2.Glasses in Water. K. Tabata, K. Yegami, and S. Moriyasu. (Proc. World Eng. Cong., Tokyo, 1929, 31, 409).

Effect of Storage of Distilled Water in Glass Ampoles on the Alkali and Total Solids Content. A. D. Matthews. (J. Amer. Pharm. Soc., 1931, 20, 767).

The Resistance of Glasses to Chemical Attack. H. Ritter (Glas und App., 1931, 12, 167, 175).
An elementary review of the problem.

The Solubility of Lead Glasses in Water. S. Moriyasu. (J. Soc. Chem. Ind., Japan, 1932, 35, 260B).

Attack of Sulphuric Acid on a Bottle Glass. L. Farcy. (Anneales des Falsifications, 1932, No. 281, 290).

The Acid Resisting Properties of Glass in Relation to its Chemical Composition and the Weathering of Glass. A Weberhauer. (Glastech. Ber., 1932, 10, 361, 374, 426, 435).
The acid resistance of glasses determined by the powder method.

The Solubility of R2O.B203.SiO2 Glasses in Water. K. Tabata and T. Moriya. (J. Soc. Chem. Ind., Japan, 1933, 36, 70-72B).

The Action of Dilute Ammonia Solution on Glass. F. Hundeshagen. (Glastech. Ber., 1933, 11, 323).

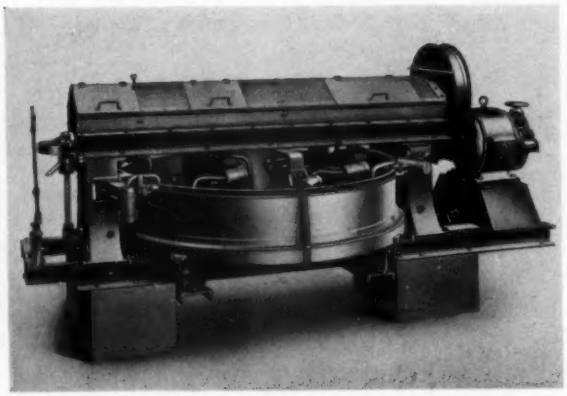
[*To be concluded*]

AMERICAN CYANAMID'S NEW DIVISIONS

Mr. H. L. Derby, President of American Cyanamid & Chemical Corporation, announces that, for the purpose of effecting closer coordination of their activities, the businesses of the following Companies in the American Cyanamid group will be merged with, consolidated into and operated as Divisions of American Cyanamid & Chemical Corporation:

American Cyanamid Sales Company,
American Powder Company,
Catalytic Process Corporation,
Fumigation Service, Incorporated,
Fumigators Supply Company, Inc.,
General Explosives Corporation,
Gypsteel Construction Company, Inc.,
Maryland Chemical Company, Inc.,
Owl Fumigating Corporation,
The Selden Company,
The Selden Research & Engineering Corporation,
Structural Gypsum Corporation.

EQUIPMENT AND SUPPLIES



The Standard Z-5 "Lancaster" Counter Current Rapid Batch Mixer with double star unit. The dust-tight cover has been removed to illustrate the internal mechanism.

The Lancaster Iron Works, Inc., of Lancaster, Pa., have recently installed one of their ZAG-5 units at the Ford City plant of the Pittsburgh Plate Glass Company.

This double Star Unit consists of two mixing stars, and ground scrapers to direct the materials into the mixing star areas. Mixing plows and kneading mullers are fitted to each star separately thus assuring sufficient flexibility for the maximum mixing results.

A patented central discharge valve is operated mechanically. Ball and roller bearings are used throughout, with gears cut to suitable proportions and with high pressure lubricating system.

The unit at the Pittsburgh Plate Glass Company was installed to handle 2600 pound batches for the production of their optical glass.

W. T. LEVITT STARTS NEW BUSINESS

A new factory for the manufacture of hospital glassware and syringes will be opened by William T. Levitt at Needham, Mass. Mr. Levitt recently resigned from the Corning Glass Works, Corning, N. Y., where he was a well known glass technologist. He plans to open the new factory late in September, and will move his family to Needham at that time.

NEW FACTORY FOR TOLEDO MOULD

The Toledo Mould Company, Toledo, Ohio, manufacturers of glassware moulds for all types of machines will begin the immediate construction of a new factory on the property acquired at 1920 Clinton Street in that city.

Up to the present time, the company has been located in the Toledo Factories Building. The change from the present quarters is the result of the recent growth of the company following the past year's stimulation in the glassware industry.

The total investment in the new building has been stated to be about $50,000. The building will be of brick and steel construction, and in these new quarters the number of employees will be increased from the 75 workers now employed.

A NEW METAL FOR MOULDS

The Miller Foundry Company, Columbus, Ohio, announces in this issue of THE GLASS INDUSTRY a new metal, said to possess many new advantages for glass container moulds. Moulds made of this metal are said to give an unusual finish to the surface of the glass, enabling the container manufacturer to supply glassware of exceptional lustre and brilliance. Other properties peculiar to this metal are toughness and durability, as well as resistance to both high temperatures and corrosion, and tests have demonstrated that moulds made of this material are of much longer life, effecting important savings to the container manufacturer both in his mould costs and in time ordinarily consumed by machinery lying idle while the moulds are being changed.

Emilite is produced in 14 different analyses, each of which meets a specific requirement in blanks, blow moulds, plungers and neck rings. It may be machined without special tools other than those used for ordinary iron moulds, and the exceptional structure of the metal imparts its velvety finish to the container without additional labor or special polishing or buffing compounds.

The Miller Foundry Company states that it has been developing Emilite for more than two years. In that time the metal has been subjected to thorough laboratory tests and has been used repeatedly in glass factories under actual operating conditions. The development of the metal has necessitated the entire remodeling of the Miller Foundry Company's plant, including the installation of a complete laboratory for testing and control purposes. Production will be under the supervision of Edward Miller and his son F. E. Miller. The sales force has been organized from trained engineers who are competent to give technical or other information desired by glass container manufacturers who may be interested in this new mould metal.

The plant of the Miller Foundry Co., Columbus, Ohio, where Emilite is made.

BANNER BOTTLE BREAKERS

The Banner Bottle Breaker Co., of New York City, manufacturers of bottle breaking machines has installed one of their bottle breakers in the Waldorf-Astoria to destroy accumulated liquor bottles.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 38° carboy ext.	Per 100 lb.	5.50	...
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	... Po. or Gr.	.25
		... Cry.	.25½
Alcohol, denatured	gal.	...	...
Aluminum hydrate ($Al(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.05¼	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.10
Antimony, metallic (Sb)	lb.	.02½	.02¾
Antimony oxide (Sb_2O_3)	lb.	...	.09
Antimony sulphide (Sb_2S_3)	lb.	...	.08
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.04	.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	56.50	61.50
90% through 100 mesh	ton	44.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.05	.05¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.08¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.02	.02¼-.02½
Powdered	In bags, lb.	.02¼	.02½-.02¾
Boric acid (H_3BO_3) granulated	In bags, lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—	lb.	...	.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	...	.06
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome oxide Green	lb.	...	.215-.25
Cobalt oxide (Co_2O_3) In bbls.	lb	...	1.25
In 10 lb. tins	lb.	...	1.35
Copper oxide Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.17-.19
Black prepared	lb.	...	.22
Cryolite (Na_3AlF_6) **Natural Greenland (Kryolith)**	lb.	.08½	.09
Synthetic (Artificial)	lb.	.085	.09
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.40
Feldspar— 40 mesh	ton	10.50-12.75	
20 mesh	ton	10.00-12.25	
Granular	ton	10.75-13.00	
Semi-granular	ton	10.00-12.25	
L. C. L. (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	35.00	...
In bags	ton	36.60	40.60
Imported (f.o.b. Seaboard)	ton	31.00	...
Formaldehyde	lb.	.05	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.		.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.		.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead)	lb.	.0625	...
In 5 Ton lots	lb.	...	.0675
Less than 5 Tons	lb.	...	.0725
Litharge (PbO)	lb.	.0525	...
In 5 Ton lots	lb.	...	.0575
Less than 5 Tons	lb.	...	.0625
Lime— Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)		1.75-2.50	...
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.03
Manganese, Black Oxide In Paper bags	ton	45.00	...
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	4.00
Nickel oxide (Ni_2O_3), black— for nickel content	lb.	...	.35-.40
Nickel monoxide (NiO), green— for nickel content	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	.08⅛	.08⅝
Powdered	lb.	.08⅝	.09⅛
Potassium carbonate	lb.	.0825	.0875
Calcined (K_2CO_3) 96-98%	lb.	.07⅞	.0875
Hydrated 80-85%	lb.	.07¼	.0775
Potassium chromate (K_2CrO_4)	lb.	...	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.07½	.09
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17-.18
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	... Po. or Gr.	.13½
		... Cry.	
Rutile (TiO_2) powdered, 95%	lb.	.15-.20	.20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se)	lb.	...	1.80-2.00
Silver nitrate (AgNO)	(100 oz.) per oz.	...	.35½
Soda ash (Na_2CO_3) dense, 58%— Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06⅛	.06⅝
Sodium chromate (Na_2CrO_4 $10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	...	.06
Sodium hydrate (NaOH) (caustic soda) Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls.	lb.	...	2.25-2.50
95% and 97% Bulk	Per 100 lb.	1.225	...
200 lb bags		1.315	1.365
100 lb. bags		1.35	1.40
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Yellow or Orange	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls.	Per 100 lb.	3.45	3.70-4.05
Flowers, in bags	Per 100 lb.	3.10	3.35-3.65
Flour, heavy, in bbls	Per 100 lb.	2.85	3.20-3.45
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.385
Tin oxide (SnO_2) in bbls.	lb.	...	.57-.60
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	2.75
Yellow orange	lb.	...	1.55
Zinc oxide (ZnO) American process, Bags	lb.	.065	.0675
White Seal, 150 lb. bbls.	lb.	.10½	.10⅞
Green Seal bags	lb.	.09⅛	.09⅝
Red Seal, bags	lb.	.08⅛	.08⅝
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04 .05

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Corhart Refractories Co. of Louisville, Ky., have prepared a very interesting pamphlet on the Corhart refractories which is being distributed to glass manufacturers this month. Containing many of the advertisements that have appeared in the trade press of late, the phamphlet is cleverly named: "Gentlemen, We Repeat"!

Tank Blocks Clay Pots

Product of

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Refractories Department

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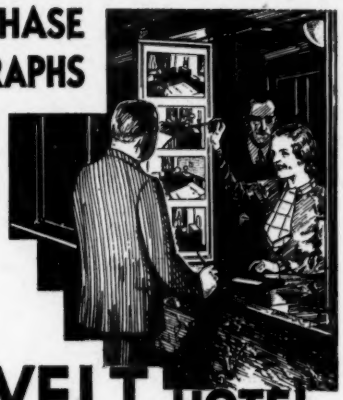

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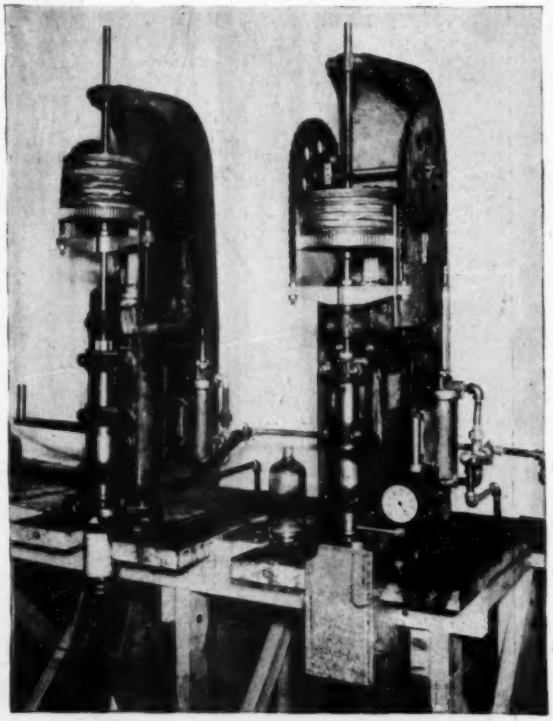

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